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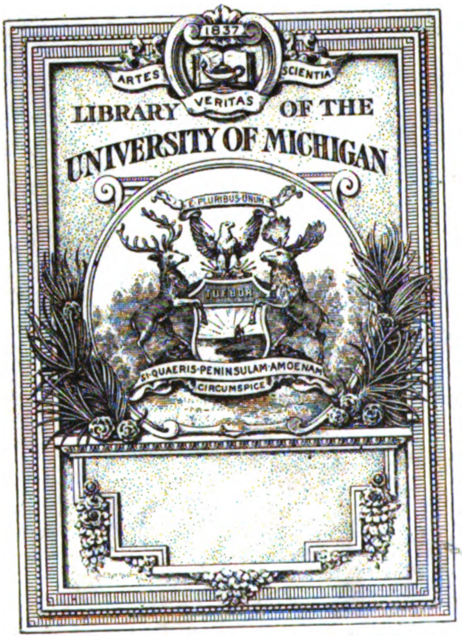

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CIVIL ENGINEERING, THE ARTS AND MANUFACTURES,

AND OF

AMERICAN AND OTHER PATENTED INVENTIONS.

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JANUARY, 1843.

Civil Engineering.

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

The theory of Coulomb upon the pressure of earth against sustaining walls, has received no other improvement from later writers than certain simplifications introduced into the direct solution of this illustrious engineer, by M. M. de Prony and Français, whose analysis afterwards extended to other hypotheses on the nature of embankments by M. Audoy, was in the last place abridged by M. Persy, through the aid of an ingenious algebraical artifice, consisting in the substitution of the sums of sines and cosines for the products. But these beautiful results, based entirely upon the hypothesis restricted to the case where the upper surface of the embankment is limited by a horizontal plane, not extending beyond the upward prolongation of the back of the wall, were not applicable, with any exactness, to the revetments of fortifications, except in the cases where the parapets, or other superincumbent loads, were but slightly elevated, with reference to the entire height of the earth to be sustained.

In his memoir of 1773, Coulomb indicated the changes to be given to his solution, on the hypothesis of a constant load of an arbitrary form, but independent of the prism of rupture; and M. de Prony, in his *Recherches sur la Poussée des Terres,* published in 1802, and, subsequently, M. Navier, in his *Leçons sur l'Application de la Méchanique aux Constructions,* have treated specially the case of uniform

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loads, composed of materials so arranged that the rupture would occur only in vertical planes; but, evidently, this hypothesis could not suit the ordinary parapets of fortifications, particularly those whose height is nearly equal to the walls then called demi-revetments. In fine, they neglected, in the solution of the question, the weight of the earth which covers the masonry, and the effect of which is rapidly increased with the thickness of the latter, whence arises the necessity of introducing it into the calculations.

In giving the solution which specially refers to the case of demi-revetments, Col. Audoy has rendered a valuable service to engineers, who had already discovered the excess in the thickness furnished by the methods then in use. Unhappily these analytical simplifications heretofore noticed, ceased to have effect in the case of irregular superincumbent loads. The engineer found himself obliged to recur to the method of direct solution adopted at first by Coulomb. In the research for the moments, notwithstanding the happy form given by M. Audoy to the expression for the pressure of earth, this mode did not get rid of the complications inherent to the very nature of the question, and which, it appears, ought in a great degree to restrict the application of new formulas in the practice of constructions. This consideration induced me to seek if it would not be possible, without sacrificing too much of exactness, to abridge the calculation for the most usual cases, by means of numerical tables, carried to a sufficient extent, or sufficiently simple rules, deduced from empyrical formulas.

I venture to hope that the long and laborious researches with which I have investigated the subject, in the first section of this memoir, will not be without usefulness to those engineers who, without having the time to execute like calculations, aim, nevertheless, at prudent economy. At least they will serve to shed some light upon the application of a theory which will only acquire the deserved degree of perfection, when, by successive efforts, these applications have been extended to the various questions which present themselves in practice, and many of which require special researches upon the physical constitution of earths considered as semi-fluids. Heretofore, the single question of the pressure of earths against indefinite masses of masonry, with uniform profiles, or sections, has alone been solved, and upon very uncertain principles. Many interesting and delicate researches, which, on account of the complication of the formulas, and of the arbitrary nature of the hypotheses, appear above the actual power of analysis, still remain to be made upon the disposition of foundations, counterforts, and of systems of relieving arches.

From the frequent necessity of the endeavor to apply questions relative to the stability of counterforts, and to the transformation of profiles into equivalent ones, it has appeared to me that they ought not to be passed by in entire silence; therefore, I have endeavored to establish, on this head, such rules or prescriptions as may enable constructors, in many cases, to avoid the uncertainty and indecision in which they are now often placed.

The comparison of the numerical results furnished by rigorous formulas, with those derived from the general profile of Vauban, has

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led me to discover that this rule, as handed down to us by Belidor, for revetments and demi-revetments, was not simply founded, as is ordinarily supposed, upon a long experience of constructions, but rather upon a precise geometrical theory, the principles of which, I believe I have been so fortunate as to discover anew. Henceforth we shall not be confined to the servile copying of a rule sanctioned by use and time, but shall be able to vary the method of the general solution, according to circumstances and available means, as that illustrious engineer himself did, and of which he offers us a particular type in the establishment of his profile.

When I undertook this work, in 1835, I intended merely to consider the most usual cases of each question, and to obtain geometrical expressions for the new formulas of M. Audoy, relating to demi-revetments. Having regard to the complication of the analytical expressions, I had succeeded in this beyond my hopes, and would have confined myself to this method of solution, which seemed so well adapted to the use of engineers entrusted with the drawing up of projects, if I had not perceived that many among them would still prefer numerical tables and empyrical rules, of an easy calculation, even though they should not embrace all the essential elements of the question. But they, at least, should be established on solid bases, and we should know the exact extent of their application, and the circumstances under which we can have confidence in them. I hope this consideration will serve as an excuse for the developments given to the analytical part of this memoir.

As to that which properly concerns the geometrical solution of the question, I will remark that having succeeded in treating with remarkable simplicity the case of demi-revetments, with vertical interior faces, which had specially occupied M. Audoy, I have been led to extend this method of solution to demi-revetments, with inclined interior faces, and without making any other hypothesis upon the inclination of the faces where the rupture ought virtually to take place, which includes embankments for cavaliers, chemins de ronde, &c., cases often occurring in the practice of construction, and which cannot be resolved with readiness, without a formidable complication of formulas. The consideration of the friction of earth upon the back of the wall, would be important in certain cases. I have sought to introduce it, without augmenting the difficulty of the solution. I have done still more; I have endeavored to establish, upon the same principles, a theory of the stability of earth, *(butée des terres,)* or of the resistance which it opposes to the action of forces which tend to displace it laterally—an entirely new theory, and which has enabled me, in the last section of this memoir, to treat various important questions relative to the stability of foundations, which we have heretofore very improperly neglected, and some of which had not escaped the penetrating sagacity of Vauban.

Such is the object of this memoir, in which, as is seen, I have not merely proposed the simplification of known formulas, but the extension even of the theory to questions not yet investigated, and which could only have been thus done with great difficulty by the process

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usually followed. In going over the last part of it, it will readily be perceived that we could, in the same manner, master the most general case, without the risk of being obscure, or of falling into any complication from doing so; but it has been thought that it would be less fatiguing, and more profitable to the readers of the *Memorial du Génie,* to confine ourselves to the various means of solving the principal cases arising in practice.

SECTION FIRST.

Calculation of the Thickness of Revetments and Demi-revetments.

Before indicating the steps by the aid of which we can transfer the formulas for demi-revetments into purely numerical tables, it is better that we should briefly recall the means of obtaining them.

Preliminary Exposition of the Notations and Fundamental Formulas.

1. Let ABCD be a profile of a revetment with a vertical back, covered by an earthen parapet, of which we will suppose, with Col. Audoy, the upper slope to be replaced by an indefinite and mean horizontal EF, meeting in G the upward prolongation of the vertical BC of the back of the wall, and in E the prolongation of the exterior slope of the parapet, the intersection H, of which with this vertical, is here supposed to be below G, so as to consider at once the most general case of the question.

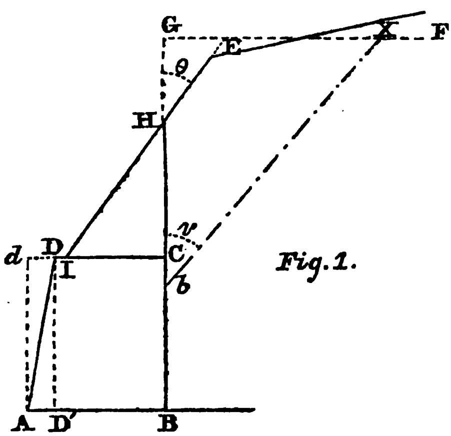

Fig. 1.

We shall call, throughout this memoir, H and *e* the height, BC, and the thickness at the base, AB, of the wall; *h* and *h'* the distances, CG and HG, from the mean level of the superior slope of the parapet to the top of the wall and to the point H.

b the distance, *d* I, from the foot of the exterior slope of the parapet to a vertical raised from A, the foot of the wall, a distance which is the same with the width, DI, of the berm, when the face of the wall is vertical.

Note.—The intimate bearing of this investigation on the dimensions of abutments of bridges, locks, wharves, and all other structures in masonry which have to sustain an earthen embankment, makes it as interesting to the civil as to the military engineer; therefore, I have thought it would not be unacceptable to the readers of the Journal of the Franklin Institute. The analysis is as beautiful and concise as the complicated nature of the problem would allow. Those who choose to pass it by can equally avail themselves of the resulting formulas and tables. J. S.

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α and θ, the angles formed with a vertical, by the natural slope of the earth and the exterior slope, EI, of the parapet.

$f = \cot \alpha$ being the coefficient of the friction of earth.

f' that of the friction of masonry.

p and p' the densities of a cubic metre of earth and of masonry.

P and M the intensity and moment, with reference to the centre, A, of the pressure exerted by the earth perpendicularly along the whole height, $BH = H + h - h'$.

δ and δ' the coefficients of stability relative to the equilibrium of rotation of the revetment around the axis, A, or of sliding along the base, AB; that is to say, the factors by which we must multiply the intensity, P, of the pressure, or its moment, M, to secure more than a strict equilibrium.

To abridge the formulas, we shall designate by

$u = \frac{h'}{H + h}$ the ratio of GH to GB, in which $h' = CG - CH$ or $h - CI \cot \theta = h - (e - b) \cot \theta$.

$a = \frac{h}{H}$ that of the mean heights of the superincumbent load, to the height, BC, of the wall.

$x = \frac{e}{H}$, $m = \frac{b}{H}$ the ratios of the thickness, AB, and of the distance, Id, to the same height.

$n = \frac{Dd}{Ad}$ the tangent of the inclination of the face of the wall with the vertical.

2. To determine the values of P and M, we ordinarily neglect the cohesion of the earth, and its friction on the back of the wall; this leads to thicknesses which must always exceed the true ones. Considering the prism, bHEXb, of any kind of earth, limited by an indefinite horizontal, EF, the weight of which being represented by Q, the total height bG by z, and the angle at b by v, we find the value, F, of the horizontal pressure, which the weight, Q, exercises upon the height, $Hb = z - h'$. In observing that this force, taken in a contrary sense, should be capable of preventing the descent of the weight, Q, along the slope, bX, by means of the friction which it conjointly with Q causes, and of which the value is evidently $f\,(F \cos. v + Q \sin. v)$ since $F \cos. v$ and $Q \sin. v$ are the perpendicular components of these respective forces to the slope, bX. The parallel components to this same slope being $F \sin. v$ and $Q \cos. v$, there results immediately the equation of equilibrium.

$$Q \cos. v = F \sin. v + f\,(F \cos. v + Q \sin. v);$$

whence we deduce

$$F = Q\frac{(1 - f \tang. v)}{f + \tang. v} = \tfrac{1}{2} p\,(z^2 \tang. v - h'^2 \tang. \theta)\frac{1 - f \tang. v}{f + \tang. v},$$

Since Q $=p$ surf. bHEX$b = p\,(b\,\text{GX} - \text{HGE})$; we shall get in supposing, for abridgement,

$$\frac{h'^2\,\text{tang.}\,\theta}{z^2} = q,\ \text{tang.}\,v = \omega,\ \text{F} = \tfrac{1}{2}p\,z^2\frac{(\omega - q)\,(1+f\omega)}{f+\omega}$$

The maximum of this last expression, in considering ω, or the angle GbX $= v$, as the only variable, ought, according to the principle of Coulomb, to give the true value of the pressure of the earth upon bH. We shall differentiate it twice with reference to this quantity, which will furnish the double condition

$$\frac{d\text{F}}{d\omega} = \tfrac{1}{2}p\,z^2\left[\frac{(f+q)\,(1+f^2)}{(f+\omega)^2} - f\right] = 0$$

$$\frac{d^2\,\text{F}}{d\omega^2} = -\tfrac{1}{2}p\,z^2\,\frac{2\,(f+q)\,(1+f^2)}{(f+\omega)^3} < 0$$

which will be completely fulfilled by taking

$$f+\omega = +\sqrt{\frac{(f+q)\,(1+f^2)}{f}}\ \text{ or }\ \omega = \sqrt{\frac{(f+q)\,(1+f^2)}{f}} - f,$$

which gives for the required maximum . . . . F $=$

$$\tfrac{1}{2}p\,z^2\frac{[\sqrt{(f+q)(1+f^2)} - (f+q)\sqrt{f}\,]}{\sqrt{f+q}}\,\frac{[1+f^2\sqrt{(f+q)(1+f^2)}\,]}{\sqrt{1+f^2}} =$$

$$\tfrac{1}{2}p\,z^2\left(\sqrt{1+f^2} - \sqrt{f^2+fq}\right)^2.$$

Substituting for ω and q their above values, we shall obtain, finally,

$$\text{F} = \tfrac{1}{2}p\left(\sqrt{1+f^2}\,z - \sqrt{f^2 z^2 + f\,\text{tang.}\,\theta\,h'^2}\right)^2 =$$

$$\tfrac{1}{2}p\,f^2\left(\sqrt{\frac{1+f^2}{f^2}}\,z - \sqrt{z^2 + \frac{\text{tang.}\,\theta\,h'^2}{f}}\right)^2,$$

for the expression of the pressure on bH, and

$$\text{tang.}\,v = \sqrt{\frac{1+f^2}{f^2}}\sqrt{f^2 + f\,\text{tang.}\,\theta\,\frac{h'^2}{z^2}} - f,$$

for the tangent of the angle GbX of the corresponding prism, which angle in the actual case, as is perceived, is not independent of the height of the superincumbent earth.

3. Remarking now that for the element, dz, of the height situated at b, the pressure is dF; this will give for its moment, taken with reference to the axis of rotation, A, of the base of the wall, the differential expression $(\text{H} + h - z)\,d\text{F}$, of which the general integral

$$\int(\text{H} + h - z)\,d\text{F} = \text{F}\,(\text{H} + h - z) + \int \text{F}dz,$$

taken from the height $z =$ GH $= h'$ to that of $z =$ GB $=$ H $+ h$, will furnish the full value of the moment M, of the pressure of the earth along the entire surface, BH.

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Supposing again, for abridgment,

$$\sqrt{\frac{1+f^2}{f^2}} = \frac{1}{\cos.\,\alpha} = c, \quad \frac{\text{tang.}\,\theta}{f} = \text{tang.}\,\theta\ \text{tang.}\,\alpha = i^2$$

the expression of the general integral will be

$$\tfrac{1}{2} p f^2 \Big\{ [(1+c^2) z^2 + i^2 h'^2 - 2cz(i^2 h'^2 + z^2)^{\frac{1}{2}}](\text{H}+h-z) + \tfrac{1}{3}(1+c^2) z^3 + i^2 h'^2 z - \frac{2}{3} c (i^2 h'^2 + z^2)^{\frac{3}{2}} \Big\} + \text{const.}$$

In reducing it to the same denominator, and in replacing h' by u (H $+h$), it will become: for $z = \text{BG} = \text{H}+h$,

$$\tfrac{1}{6} p f^2 (\text{H}+h)^3 \Big[1 + c^2 + 3 i^2 u^2 - 2c(1+i^2u^2)^{\frac{3}{2}} \Big] + \text{const.}$$

and for the other limit $z = \text{GH} = h'$,

$$\tfrac{1}{6} p f^2 (\text{H}+h)^3 \Big\{ [3(1+c^2)u^2 + 3 i^2 u^2 - 6c(1+i^2)^{\frac{1}{2}} u^2](1-u) + (1+c^2)u^3 + 3 i^2 u^3 - 2c(1+i^2)^{\frac{3}{2}} u^3 \Big\} + \text{const.}$$

which gives, in subtracting this latter from the preceding,

$$\text{M} = \tfrac{1}{6} p f^2 (\text{H}+h)^3 \Big\{ (1+c^2)(1-3u^2+2u^3) - 2c(1+i^2u^2)^{\frac{3}{2}} + 2c(1+i^2)^{\frac{1}{2}}(3-2u+i^2u)u^2 \Big\},$$

or, finally, in substituting for c and i their values,

(*a*) $\text{M} = \tfrac{1}{6} p\,(\text{H}+h)^3 \times$

$$\left\{ \begin{array}{l} (1+2f^2)(1-3u^2+2u^3) - \dfrac{2\sqrt{1+f^2}}{f^2}(f^2 + f\,\text{tang.}\,\theta\,u^2)^{\frac{3}{2}} \\ + 2\sqrt{1+f^2}\sqrt{f^2+f\,\text{tang.}\,\theta}\,\left(3u^2 - 2u^3 + \dfrac{\text{tang.}\,\theta}{f} u^3\right) \end{array} \right\}.$$

We will obtain in the same way, for the expression of the pressure along the entire height, BH,

(*b*) $\text{P} = \tfrac{1}{2} p \left[\sqrt{1+f^2}\,(\text{H}+h) - \sqrt{f^2(\text{H}+h)^2 + f\,\text{tang.}\,\theta\,h'^2}\right]^2$
$= \tfrac{1}{2} p\,(\text{H}+h)^2 \left(\sqrt{1+f^2} - \sqrt{f^2 + f\,\text{tang.}\,\theta\,u^2}\right)^2,$

and for the corresponding value of tang. v,

(*c*) $\text{tang.}\,v = \sqrt{\dfrac{1+f^2}{f^2}}\sqrt{f^2 + f\,\text{tang.}\,\theta\,u^2} - f.$

4. In replacing (1), in the various expressions for f, the cot α, and for u the ratio $\dfrac{h'}{\text{H}+h}$, it will be easy to establish their identity, except in the notation, with those obtained by M. Audoy.

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Making this substitution, particularly in the values of P and tang. v, they become

$$(d)\quad P = \frac{p}{2 \sin.^2 \alpha}\left[H+h - \cos. \alpha \sqrt{(H+h)^2 + \text{tang.}\, \theta \text{ tang.}\, \alpha\, h'^2}\right]^2$$

$$(e)\quad \text{tang.}\, v = -\frac{1}{\text{tang.}\, \alpha} + \frac{1}{\sin. \alpha\, (H+h)} \sqrt{(H+h)^2 + \text{tang.}\, \theta \text{ tang.}\, \alpha\, h'^2}$$

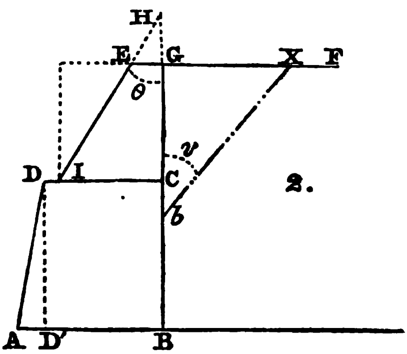
expressions in effect identical with those referred to, when we replace the angle α by ϕ, h' by a, and suppose $h' = h$ or IC and CH $= 0$ as in that case.

5. As these formulas serve as the basis to the whole of the first part of this memoir, it seemed necessary to dwell a little upon their demonstration, while, at the same time, putting them in a form which will facilitate greatly the discussion and numerical calculation in each case. This is the proper place to remark that the quantity

$$u = \frac{h'}{H+h} = \frac{h - (e-b) \cot. \theta}{H+h},$$

always comprised between zero and unity, only ceases to be an implicit function of the thickness, e, of the revetment, when $b = e$, or when the foot, I, of the exterior slope of the parapet, coincides with the interior edge, C, of the top of the wall, which then simply gives

$$u = \frac{h}{H+h} = \frac{a}{1+a}$$



6. On the other hand, the preceding analysis is only applicable to the case in which the point G (fig. 1) is situated above H; if the contrary happens, as is shown in fig. 2, the triangle EGH is no longer a part of the prism of pressure, GbX, and the expression $\frac{1}{2}$ tang. $\theta\, h'^2$ for its surface, should not enter into the expression for Q; which is the same thing as making h' and u zero throughout the calculation, and leads at once to these results:

$$\text{tang.}\, v = \sqrt{1+f^2} - f = \text{tang.}\, \tfrac{1}{2} \alpha$$

$$P = \tfrac{1}{2} p \left(\sqrt{1+f^2} - f\right)^2 (H+h)^2 = \tfrac{1}{2} p \text{ tang}^2\, \tfrac{1}{2} \alpha\, (H+h)^2$$

$$M = \tfrac{1}{6} p \left(\sqrt{1+f^2} - f\right)^2 (H+h)^3 = \tfrac{1}{2} p \text{ tang.}^2\, \tfrac{1}{2} \alpha\, (H+h)^2\, \tfrac{1}{3} (H+h),$$

which returns to the hypothesis of a uniform load, the starting point of M. Français' calculations.

7. As to the equations of equilibrium, which, in the general hypothesis of fig. 1, give the thickness, e, of the base of the revetment, ABCD, they become (1):

In the first place, on the supposition of sliding upon the foundation,

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$$(f) \quad \tfrac{1}{2} f' p' (2e - n\mathrm{H})\mathrm{H} + \tfrac{1}{2} f' p (e-b)^2 \cot\theta = \delta' \mathrm{P};$$

in the second place, on that of turning around the axis of rotation A,

$$(g) \quad \tfrac{1}{2} p' (e^2 - \tfrac{1}{3} n \mathrm{H}^2)\mathrm{H} + \tfrac{1}{6} p \cot\theta (e-b)^2 (2e+b) = \delta \mathrm{M}.$$

The first term of these equations represents, respectively, the friction or the moment due to the weight of the wall, and the second, the friction or the moment due to the weight of the prism of earth, ICH, which rests on the top of the wall.

8. On account of $u = \frac{h - \cot\theta\,(e-b)}{\mathrm{H}+h}$ and of the radicals which enter in the value of P and M (3), these equations will be generally as high as the 4th and 6th degrees in e, except in the specified case (5) of $b=e$ and of $u = \frac{h}{\mathrm{H}+h}$, when they at once become:

(*h*) 1st for the case of sliding, $e = \frac{\delta' \mathrm{P}}{f' p' \mathrm{H}} + \tfrac{1}{2} n\mathrm{H}$

(*i*) 2nd for that of rotation, $e = \sqrt{\frac{2\,\delta\,\mathrm{M}}{p'\mathrm{H}} + \tfrac{1}{3} n^2 \mathrm{H}^2}$

P and M being then calculable *a priori.*

9. The equations (*f*) and (*g*) will likewise be reduced to the second degree in the case of fig. 2, for which (6) h' and $u=0$; but then it is necessary to replace the triangle ICH by the trapezium ICGE, in virtue of which they will become,

First, for the case of sliding upon AB,

$$f'p'(2e - n\mathrm{H})\mathrm{H} + f'ph(2e - 2b - h\,\mathrm{tang.}\theta) = \delta' p\,\mathrm{tang.}^2 \tfrac{1}{2}\alpha\,(\mathrm{H}+h)^2;$$

which gives immediately

$$(j) \quad e = \frac{\delta' p\,\mathrm{tang.}^2 \tfrac{1}{2}\alpha\,(\mathrm{H}+h)^2 + f'p'n\mathrm{H}^2 + f'ph(2b + \mathrm{tang.}\theta\, h)}{2f'(p'\mathrm{H}+ph)};$$

secondly, for the case of rotation,

$$\tfrac{1}{2}p'\mathrm{H}e^2 - \tfrac{1}{6}p'n^2\mathrm{H}^3 + \tfrac{1}{2}p(e^2-b^2)h - \tfrac{1}{2}ph^2\mathrm{tang.}\theta(b + \tfrac{1}{3}h\,\mathrm{tang.}\theta) =$$
$$\tfrac{1}{6}'\delta p\,\mathrm{tang.}^2 \tfrac{1}{2}\alpha\,(\mathrm{H}+h)^3;$$

which likewise gives

$$(k) \quad e = \sqrt{\frac{\delta p\,\mathrm{tang.}^2 \tfrac{1}{2}\alpha\,(\mathrm{H}+h)^3 + p\cot.\theta\,(b + h\,\mathrm{tang.}\theta)^3 - p\cot.\theta\, b^3 + p' n^2 \mathrm{H}^3}{3(p'\mathrm{H}+ph)}}$$

10. Thus the thickness of revetments can be calculated directly from these last formulas, whenever CG or h will be less than CH $= (e-b)\cot\theta$, and, in the contrary case, it will be necessary to recur to the general equations of number 7, which will be solved by the method of successive substitutions, or by approximate trials. These attempts need never be very long, since the solution does not aim at rigorous exactitude, and as we must know, from the very nature of the question, limits more or less approximating to those of the value of the unknown quantity.

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11. On this subject, it is as well to remark, that the knowledge of these limits, fixing, as they nearly do, the position of the foot, I, of the exterior slope of the parapet, with reference to the back of the wall, enables us to change the question into the solution of an equation of the first or second degree, in considering IC or CH as given *a priori*, and taking, as M. Audoy did, for a new unknown quantity, not the thickness of the base of the revetment, but the distance, b, of the point, I, from the vertical raised from the point, A. Making, in fact, the known quantity

$$IC \text{ or } e - b = c,$$

and substituting for e its value, $b+c$, or for b its value, $e-c$, in the equations (f) and (g), they will give directly in solving them, with reference to $(b+c)$ or e, and observing that P and M are calculable *a priori*:
Firstly, for the case of sliding, $b+c$, or

$$e = \frac{\delta' P}{f' p' H} + \tfrac{1}{2} n H - \tfrac{1}{2} \frac{p c^2}{p' H} \cot \theta;$$

secondly, for that of rotation, $b+c$, or

$$e = -\frac{p}{p'} \frac{\cot \theta c^2}{2H} + \sqrt{\frac{2 \delta M}{p' H} + \frac{p^2}{p'^2} \frac{\cot^2 \theta c^4}{4 H^2} + \frac{p}{p'} \frac{\cot \theta c^3}{3 H} + \tfrac{1}{3} n^2 H^2}$$

in neglecting the root foreign to the question.

These preliminary remarks seemed necessary, in order to shed the necessary light on the investigations made in this section; but as by the very simple process of the transformation of profiles, which will be presented farther on, we can always change the case where the outer face of the revetment is in batter into that where it is vertical, we shall first consider the latter which presents less difficulty in the comparison of the formulas and in the formation of the tables.

CHAPTER FIRST.

Vertical Revetments considered on the hypothesis of Overturning by Rotation.

12. For walls with vertical faces, we ought to suppose $n = 0$ throughout all the preceding formulas, and to consider the letter b as representing the width of the berm ID, fig. 1.

At first, considering the case of slight loads, we can, with M. Français, neglect the influence due to the weight of the prism of earth ICH, which rests immediately upon the wall, and suppose the triangle GHE complete, in correcting the error of the hypothesis by means of a suitable determination for the position of the horizontal EF. We then fall (6 and 8) upon the formula

$$(l) \qquad e = \text{tang.} \tfrac{1}{2} \alpha (H+h) \sqrt{\frac{\delta}{3} \frac{p}{p'} \frac{(H+h)}{H}},$$

given by this author, and in which the coefficient δ has been taken equal to 1.8, so as to obtain a stability equivalent to that of Vauban's

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revetment, ten metres high, without counterforts, sustaining a superincumbent mass of earth, two metres in height, and considered on the hypothesis of the earth and masonry being of mean densities, for which it is supposed that $\frac{p}{p'} = \frac{2}{3}$, $a = 45°$ or the tang. $\frac{1}{2}a = 0.4142$.

13. Considering, besides, the case without a load, or when it is so small that we can neglect $\frac{h}{H}$ under the radical, we fall upon the very simple formula

$$(m) \qquad e = \text{tang.}\ \tfrac{1}{2}a\sqrt{\frac{\delta}{3}\frac{p}{p'}}\,(H+h),$$

which is analogous to that by which certain engineers take the mean thickness of revetments to be proportional to the total height, including that of the superincumbent load of earth.

14. From the hypotheses which have been used in obtaining formula (l) of M. Français, it is evident that the pressure has been increased at the same time the resistance of the revetment has been lessened; which leads to results where the error is only appreciable in the case of low scarps, or heavy superincumbent loads. In effect let us suppose $H = 0$ or very small relatively to $H + h$, it is clear that the thickness given will be of an unlimited value, whereas, it should really be finite, and indeed quite small, as is shown by the more rigorous formulas of M. Audoy. Now it is very worthy of remark, that the rule which simply makes the thickness, e, proportional to $H + h$, has not the inconvenience in question, although it still exaggerates this thickness for very low revetments—a circumstance evidently arising from the fact that in neglecting h under the radical, there has been a compensation of errors, which have a great influence in the high values of the ratio of h to H. This will be established more rigorously in that which follows.

(To be continued.)

Extracts from the Eighth Report of L. O. Reynolds, *Esq., Chief Engineer of the Central Railroad and Banking Company of Georgia.*

The track has been laid, and the road completed to Station No. 15, (west of the Oconee river and 152 miles from this city;) and a further distance, equal to five miles of finished superstructure, has been done, leaving not more than thirty-three miles to be laid to reach the terminating depôt at Macon.

It is confidently expected, also, that the superstructure of the Monroe Railroad, which is now laid only to Griffin, (sixty-one miles from Macon,) will be extended to the Western and Atlantic road at Whitehall, (101 miles,) and that the state road will be in operation fifty-two miles; making in all a distance of *three hundred and forty-three miles of continuous railroad from the city of Savannah,* by the 4th of July next.

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The business of the road since the opening of the fall season, shows a great improvement on that of last year. Cotton is flowing in upon us in great quantities, and the prospect of a profitable winter's work is very encouraging. Our present equipment of motive power is the same as the last year, with the addition of ten eight-wheel burthen cars, nearly ready to put on the track.

We could, with our present number of engines and cars, bring in about 12,000 bags of cotton per month, should that quantity offer; we have, thus far, kept the road clear, or so near it as never to have had more than two days work accumulate; and I apprehend we shall have no difficulty in doing so during the balance of the season.

In compliance with the general desire of the citizens, and a large portion of the stockholders of the Company, a reduction has been made in our rates of freight, compared with the tariff of last year. Whether the measure will result in increased profits to the Company, or the reverse, remains to be tested. The public appear to be satisfied with the present arrangement.

The total receipts for the year ending October 31st, are as follows:

For freight, ...	$91,456 31	
" passengers, ...	30,167 00	
" transportation of the U. S. mails, .	11,912 00	133,535 31

The current expenses have been as follows,

For maintenance of way, ...	28,377 47	
" conducting transportation, including salaries of agents, conductors, clerks, laborors, and various contingent expenses,	21,269 55	
" maintenance of motive power, repairs of cars, engines, &c., including rebuilding the engines Georgia and Tennessee,	15,188 58	
" fuel and water for engines, . .	4,810 80	
" oil and tallow for engines and cars,	1,107 79	70,754 19

Leaving a net profit of	$62,781 12
To this amount may be added,	
Transportation of materials for the construction of road,	10,000 00
Actual net earnings of the road, . .	$72,781 12

This sum, if applied to the capital expended in the construction of the portion of the road in actual use, amounts to about five and a half per cent.

The distance performed by all the engines, during the year, is as follows: Atlantic, 21,065 miles; Oconee, 19,792; Macon, 17,120; Savannah, 17,941; John Bolton, 9,818; Oglethorpe, 8,469; Tennessee, 3,723; Georgia, 3,509. Total number of miles run, 102,145. The quantity of fuel used in performing this service, is 1,358 cords, or an average of one cord for every $75\frac{21}{100}$ miles run.

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The aggregate amount of the expenses of working, and keeping in repair, the road and machinery, with the transportation expenses, being, as before stated, $70,754 19, gives us the rate of $69\frac{26}{100}$ cents per mile, as the average cost of running a train for the last year. The investigations of the Chevalier de Gerstner on this subject, show that the average of all the railroads in the United States, in operation in 1840, for this item, was about one dollar per mile. It should be borne in mind that a much larger business might be done on our road without a corresponding increase of expense. The present number of superintendents, agents, clerks, &c., would not be materially increased if the business were doubled.

It is proper to remark, however, in relation to the maintenance of way, that we have not yet felt the full expense of renewing decayed parts, for more than half of our line. The average cost per mile for this branch of our expenses, has been about $200 for the last year, on the part of the road in operation. We may expect that whenever the wooden superstructure reaches the maximum of decay, the expense will be double this amount. We find no difficulty in making contracts with persons along the line, for the supply of timber for keeping the superstructure in repair, on favorable terms; and in all cases where it can be done at a reasonable cost, we are substituting cypress timber for the pine which was used in the original construction, as the latter decays. My observation on the subject of the decay of timber in our road, has led me to the conclusion that the renewals of decayed parts will be equivalent to an entire re-construction of the wooden portion of the road once in six years.

There has been much written and said on the subject of preparing the timber by the use of mineral substances, so that it may resist the ordinary causes of decay; and many experiments are in progress, in various parts of the country, to test the efficiency of the several modes proposed to effect this most desirable object.

The plan which appears to find most favor in England, where it has been very extensively adopted, is the process of saturating the timber with a solution of corrosive sublimate, termed "Kyanizing." There have, however, been various other modes proposed, which if on experiment, are found to be successful, will be much less expensive, and better adapted to the circumstances of the public works in this country. Among these, the process employed by Dr. Earle, of Philadelphia, appears to have taken the lead. He uses, instead of corrosive sublimate, a combination of the sulphates of iron and copper. Public opinion appears to be much divided on the merits of this "process." My impression is, that so far as our own work is concerned, the best policy is to await the result of the experiments that are being made, on a very extensive scale, on the Western and Atlantic road, in our own state, and to a considerable extent on the roads of a neighboring state. The abundance of excellent timber throughout the whole district of country traversed by our road, confirms me as to the propriety of such a course.

The subject of "maintenance of way" is one of the most important of all the matters connected with the management of a railway.

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It is a great error to suppose it the best policy to cut down the expenses of repairs of road to the lowest possible sum that will keep the road in operation. A proper investigation of the subject will, in most cases, show that an over-strained economy in this branch, will result in constant derangement of machinery, involving increased expenses in the mechanical department, more than equivalent to the apparent saving. To this may be added, the vexatious delays of passenger and mail trains, resulting from trifling accidents to the machinery.

From the best information I have on this subject, in relation to railroads in the Southern States, it appears that the force required to maintain the roads, is an average of about one man to a mile, while we have for a distance of 147 miles, only sixty men. We must, therefore, as the wood work advances in decay, look forward to this number being doubled, at least.

There are no means so effectual in regulating and controlling the expenditures of a railway, as a system by which each item of the multitudinous expenses may at any time be exactly known, and each individual in the service of the Company be at all times made accountable for the particular branch of outlay under his charge, from a spike to a locomotive engine.

It is difficult to perfect such a system while the work is in an unfinished state, but we have endeavored to approach as near as possible to it, and in another year every branch of the service will be brought under systematic regulations.

The following is a list of the persons in the service of the Company, on the part of the road in operation:

Transportation Department.—Superintendent, 1; agents, 7; clerks, 4; conductors, 3; laborers, 22—36.

Road Department.—Road master, 1; carpenters, 9; laborers, 50—60.

Mechanical Department.—Principal machinist, 1; master carpenter, 1; finishers, 3; engine men, 5; apprentices, 3; smiths, 2; strikers, 2; firemen, 5; jobbers, 2; carpenters, 5; pattern maker, 1—30.

Total, 126.

It is intended to provide an ample supply of engines and cars, in anticipation of the probable amount of business that may offer during next season, when the road shall have been extended to its terminus.

Our present engines are what are termed the third class, that is, they are of the lightest description usually made at the manufactories where they were obtained. Their maximum net load, at ordinary speed, on our road, is about sixty-five tons, or 350 bales of cotton, of medium weight. It will be necessary to have engines of greater power, when a further number is ordered, and I feel confident that among the several improvements that have been made recently, with a view of increasing the power without adding materially to the weight on each driving-wheel, we shall be able to select such as will draw at least twice the burthen of our present ones, without materially increasing the stress on the road.

In conclusion, I think I can with confidence congratulate the stock-

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holders and the citizens, on the favorable aspect of our enterprize, and its obvious beneficial effect on the business and prosperity of our city in particular. I think we may venture to say, that there is not a city south of the Potomac which has, during the unprecedented pressure of the times for the last two years, shown so decided indications of improvement as Savannah; there has been a greater number of buildings erected during that time than for the same period in many years; our population is rapidly increasing, while that of neighboring cities is declining, and our citizens are animated with the brightest hopes of the future.

Savannah, Nov. 7th, 1842.

Letter from Charles Moering, Esq., Engineer, to Messrs. Eastwick & Harrison, Locomotive Builders, corner of Twelfth and Willow Street, Philadelphia.

Gentlemen:—In complying with your request to give you my opinion about your Locomotive Engines, I feel called upon to state the grounds that make this opinion what it is.

I do this in view of the interests of science, not intending to pass a mere encomium upon the productions of your establishment. Every engineer is, no doubt, conversant with the fact, that the power of a locomotive engine not only depends on the harmonious proportions of boiler and cylinders, and on the clever mechanical arrangement to work the pistons and transfer motion to the driving wheels; but every engineer must be also aware of the importance of another fact, viz: *the manner in which this power is made available in order to draw a maximum load, at a maximum speed, on a railroad.*

In examining this point, we find that a fulcrum is required to enable the steam power to act upon the weight, or the load to be drawn. This fulcrum in the locomotive engine, is evidently the grip of the driving wheels on the rails, meaning the friction between both, or *adhesion,* as it is technically called. Let a locomotive engine be ever so powerful, but take away the aforesaid friction, and the wheels will slip, the engine will draw nothing. This adhesion, derived from the pressure of the weight of the engine, must, therefore, bear a certain proportion to the latter. Its maximum will be obtained by throwing the largest, its minimum by placing the smallest amount of the engine's weight on the driving wheels. The minimum, however, has at no time been a desideratum, as the largest amount of adhesion is required for enabling an engine of a given power to draw a maximum load at a maximum speed.

In the six wheeled American engine, (the true offspring of American mechanical talent, as possessing a fore truck, which affords a most opportune facility for turning curves,) there is but *one* axle to bear the aforesaid proportion of weight; and this axle is the driving axle. On its position, therefore, depended the amount of weight to be made available for producing friction. As it was found impossi-

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ble, as well as improper in practice, to place this *single* driving axle under the centre of gravity, for the purpose of equilibrating the entire weight of the engine, there remained but two other positions, viz: *behind and close before the fire-box.*

To illustrate the effect in both cases, let us suppose two engines, A and B, each of 12 tons weight in running order, with cylinders, boilers, and driving wheels of the same dimensions, and performing the same amount of duty, on two roads of exactly the same kind.

In the engine A, with the driving axle *behind* the fire-box, it was found that only *half* of its weight was brought into action for the purpose of producing friction, amounting in this case to $\frac{12}{2} = 6$ tons.

In the engine B, with the driving axle *before* the fire-box, *two thirds* were found available for the same purpose, equal to $\frac{2 \times 12}{3} =$ 8 tons. The ratio of *adhesion* is, therefore, A : B = 6 : 8, meaning that the engine B possesses a surplus of two tons in its adhesive power, *and, consequently, in its capability of drawing loads.*

In further examining our subject, another question arises, concerning the effect of the given ratio of adhesion on the rails. In the engine A we have, as mentioned, six tons on the driving axle, and, therefore, three tons on each driving wheel. In the engine B, however, we find eight tons on the driving axle, and, consequently, four tons on each driving wheel. The proportion of *weight* on the rails is, accordingly, A : B = 3 : 4.

Supposing these two engines to run at the same speed, S, and assuming the stress by impact upon the rails to be represented approximately by the speed multiplied into the weight imposed upon each driving wheel, then each line of rails would be percussed by A, with $S \times 3 = 3$ S, and by B, with $S \times 4 = 4$ S.

This gives a ratio of *impact* A : B = 3 S : 4 S or A : B = 3 : 4; meaning, for the sake of practical illustration, that the engine B will ruin the rails, take them to be thirty eight pounds per yard, after the lapse say of nine years; whilst the engine A will produce the same deterioration only after the space of twelve years, supposing the amount of traffic and other conditions to be the same in both cases.

Although no actual observations of this nature have been made with regard to the rails, yet the average duration of the wrought iron tires on the driving wheels, proves the above proportion not to be an incorrect one. The duration of tires on engines, with the driving axle *behind* the fire-box, has been found to exceed the duration of those on engines with the driving axle *before* the fire-box; and taking the latter to be nine months at an average, the duration of the first has been found to amount to from twelve to fourteen months.

Wrought iron rails being manufactured in the same way as tires, it can be but a fair assumption, that the duration of rails will admit of the same proximate scale given in the above proportion of impact.

This brief exposition, backed by the ratio of *tractive power*, A : B = 6 : 8, and by the proportion of *duration*, A : B = 3 : 4, makes it ob-

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Plate I. Vol. V. 3rd Series

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vious why the *diminution of impact* in the engine B, possessing a superior power of traction, was found of such great importance, and has thus constantly occupied the attention of the American machinists and engineers. In pursuance of this notion, the eight wheeled engine was started with *two* driving axles, one *before* and the other *behind* the fire-box.

Supposing such an engine C, to weigh twelve tons, in running order, and of the same dimensions as A and B, the weight on the two driving axles was found to be also *two-thirds*, or eight tons, yet pressing upon the road, on the four points of contact, only with $\frac{8}{4}=2$ tons.

The proportion of *adhesion*, or *tractive power*, is, therefore, A : C =6 : 8, B : C=8 : 8, A : B : C=6 : 8 : 8.

The ratio of *impact*, or *deterioration of the rails*, being C : A=2 . 3, C : B=2 : 4, C : A : B=2 : 3 : 4.

From this we may infer that rails lasting but nine years under the performance of the engine B, and twelve when traveled upon by the engine A, will not meet with their ulterior destruction before eighteen years, when engines of the kind C, are running upon them under the aforementioned suppositions.

I can, therefore, but applaud your resolution of building systematically no other engines but those with eight wheels—four driving and four truck wheels. However, I feel myself called upon to impress you with the advantages that must necessarily result when the number of driving wheels can be augmented to six or eight, without losing that beautiful characteristic of the American engine, viz: *the free vibrating truck*, which in its office of piloting the engine along the track, I think invaluable for the American railroads, with their sharp turns and light superstructure.

An engine, D, with *three*, and an engine, E, with *four* driving axles, lending an opportunity to make their *whole* weight available for adhesion, which then would be that due to the maximum weight of twelve tons, in the given case, would certainly possess the greatest tractive power, and yet injure the road in a much less degree. The proportions of adhesion, or tractive power, would be the following ones, supposing in every case that the engine possesses sufficient power to slip her wheels in pulling against a fixed point, A : B : C : D : E=6 : 8 : 8 : 12 : 12; and the proportions of impact, or deterioration of the rails, B : A : C : D : E=4 : 3 : 2 : 2 : 1½.

I am aware of all the difficulties attending what I propose, but I feel, nevertheless, confident that "flexible coupling rods," permitting all the axles, with the exception of the main driver, to conform to the radii of curves, are within the pale of practical feasibility. Only on this condition should I think myself justified in preferring engines with a greater number of driving axles than two, were I even inclined to overlook the greater complication that such a mechanical arrangement must require. I reckon simplicity to be one of the cardinal virtues in any mechanical apparatus, and of the most absolute necessity in the locomotive engine.

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After this digression, permit me, gentlemen, to come back to the *eight wheeled engine*, C, as the subject of my disquisition. Great as the improvement promised to be, in introducing the aforesaid engine, the advantages derived therefrom for the preservation of the rails, were, however, nearly lost. The difficulty consisted in the stiff connexion of the fire-box, boiler, smoke-box, and pedestals of the driving wheels, with the frame, which acted like a lever. Whenever one pair of driving wheels was raised, by some irregular elevation in the track, resulting from its bad condition, the other pair, in consequence of the springs not acting quick enough to force them down, were momentarily lifted up by the frame, consequently without bearing their due proportion of weight; and, on the contrary, when one pair was passing over a depression in the road, the other again, for the same reason, had to sustain nearly the whole amount of weight originally allotted to both driving axles—the truck wheels always acting as a fulcrum, and the frame, with its fixed pedestals and the axles therein revolving, as a lever.

This could not help injuring the road nearly in the same degree as the engine B; nay, the effects were still more injurious to the engine C, itself, as in the case of the main driving axle being suspended by the frame, in one of the aforesaid elevations or depressions of the other driving axle, the former received its rotary motion from the pistons without its fulcrum or adhesion to the rails.

It is but just to say, gentlemen, that you saved the eight wheeled engine from becoming a mere notion, and that owing to your exertions, it has been brought to such a state of perfection as ought to make the old six wheeler, of the kinds A and B, quite obsolete. It is, furthermore, but justice to state, that your special adaptation of the lever, or balancing beam, to the use of locomotives upon railways, obviated the aforesaid difficulties in such a manner as to leave but little to desire; and here I regret to say, that some of the northern railroads in Germany—notwithstanding the unqualified recommendation of so able an engineer as Mr. C. E. Detmold—have not adopted engines with your improvement.

I consider the balancing beam—supported in its centre by a vertical shaft, resting on springs that are attached by the pedestals to the frame, and stayed on its ends by two vertical pins abutting against the two driving axles—as possessing, in an eminent degree, the two indispensable qualities—*first*, of equalizing the weight on both driving axles, in whatever condition the road may be, and, therefore, producing in an eight wheel engine of twelve tons, a constant and equal adhesion of eight tons, yet pressing the rails with but two tons; and *second*, of furthermore diminishing the very ratio of impact as given above, the weight of the engine being suspended in the middle of the lever beam, causing it to fall only half the depth of any of the driving axles, in their passage over any short or sudden depression in the track, while the engines A and B must go down the whole depth, as supported by one axle alone, which by increasing the height of fall, must add to the power of the percussion, and, therefore, ruin the road

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even in a shorter period than the proportionate number of twelve or nine years.

But this is not alone what distinguishes your engines, the balancing beam of your arrangement being now used by nearly all the engine builders of note in the United States, after having purchased the patent right from you, which at once bespeaks the great merit and usefulness of your improvement.

It is, besides, the very simplicity of your engines that must engage the attention of even the least observing. Instead of four eccentrics, four eccentric rods, four latches, and a complicated arrangement to put them in and out of gear, by an extra hand lever—thus making three hand levers altogether—you have but two eccentrics, two eccentric rods, no latches, and a simple arrangement of the reversing valve; the whole to be handled by one and the same lever, and this, too, by moving it in exact accordance with the required movement of the engine.

It is true that in reversing you lose in speed, as the lead of the slide no longer takes place; but this loss I think of no moment, as it only happens when the engine is backing. Besides, the position of your forcing pumps is such as to prevent the freezing of the water—an advantage of great importance with locomotion in northern climes.

Gentlemen, this is my candid opinion about your eight wheeled engines, and you are welcome to make any use of this document. Permit me to avail myself of this opportunity to thank you for your readiness, and the frank and open way in which you satisfied my desire for information; and allow me to assure you that the modest and unostentatious manner in which you spoke of your engines—trusting more to their own merits than to puffing and boisterous recommendations—has most favorably impressed me with your own personal character.

I am, gentlemen,
Your's, respectfully,
CHARLES MOERING,
Captain of Engineers in the Austrian Army.
No. 342 Chesnut Street.

Philadelphia, September 1st, 1842.

Facts and Observations on Four and Six Wheel Engines.
By JOHN HERAPATH, ESQ.

[CONTINUED FROM VOL. IV, PAGE 243.]

Great Western Railway.

So much has been said upon the subject of the Great Western Railway, in our Magazine, that it will be scarcely necessary for us to enter into any description of it. Distinguished from all other railways by the breadth of its gauge, or the distance between its rails, (seven feet) it has long been regarded as a great experimental line. Mr. Brunel, the engineer, and his friends, anticipated great advantages from this broad gauge, while the generality of engineers think it too

wide, and that a gauge of six feet would be amply sufficient for all purposes. At present, experience has settled nothing in this plan superior to the other or old breadth of four feet eight and a half inches. Mr. Brunel expected that his line was not only to be much safer, but to work considerably more economically than any other. His expectations, however, do not appear as yet to have been realized. Accidents have not been less in number, or less serious, when they have occurred upon the Great Western, than upon the London and Birmingham, or other lines. It must, however, be conceded, that the engines and carriages upon this railway very rarely get upset, or, as it is technically called, "thrown off their legs," though they have not shown more tenacity to keep the rails than other engines and carriages. Some have questioned the advantage of even this, and think a less obstinacy in the engines in keeping their legs, would be safer for the passengers, as giving a greater chance to the engines of being thrown out of the way. On the score of humanity to the poor engine-drivers, this is a doctrine we cannot assent to, even supposing it true.

Besides the wide gauge, the distinguishing feature of this line is, that the whole of the rails are laid on longitudinal wooden bearers. Here, again, is another question between engineers, as to whether these are preferable for a railway or not. According to the experience upon the Hull and Selby Railway, and Midland Counties, and Bristol and Exeter,* we should be inclined to think that the draught upon them is considerably more at certain seasons and in particular states of the weather, than when the rails are laid on cross sleepers, or stone blocks. For example, in hoar frost, it is put beyond a doubt, both by the observations of Mr. Gray, of the Hull and Selby, and of myself, on the Bristol and Exeter Railway, that hoar frost is often found upon rails laid on longitudinal bearers, when no symptoms whatever of it appear on rails laid on cross sleepers. In wet weather, again, the rails almost ever act as syphons to collect the wet between them and the timbers, which very much tends to increase the draught. In dry weather it is doubtful if there is much difference of draught between the rails laid in this way, or upon either of the other plans, though I should be inclined to think, from my observations on the Midland Counties Railway, that even here the draught is heavier than it is upon cross sleepers or stone blocks. On the other hand, however, I perfectly agree with Mr. Brunel, and had, indeed, made a note in my travels over the Great Western Railroad to the same effect, namely, that when the road is bad, by unequal subsidence of the ground, the plan of strong longitudinal bearers is generally safer than that of cross sleepers, from the disposition which the rails have on the longitudinals not to follow every deflexion of the road. For example, on a very troublesome piece of ground which the Great Western have below Swindon, they were enabled to continue the traffic under circumstances which I feel quite certain would have stopped it on any other line not so constructed. One of the rails on the down line, I should think was full six inches, or more, lower than the other

* Jour. Frank. Inst., vol. iv, pp. 19 and 77.

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rail, for some considerable distance, and the ground beneath it appeared to be in a most rotten and unsafe state for anything like isolated supports. Yet over this piece of ground the trains traveled in the most perfect safety, and without the least apprehension of danger from any one, owing to the firm and united support given to the rails by the longitudinal bearers. Besides, by Mr. Brunel's plan of longitudinal bearers, there is a much greater bearing surface than with cross sleepers, and, consequently, bad ground at any particular part is less distressed by the superincumbent weight of the traveling trains. But were the ground sound, from what I have seen, I think there can be no doubt that cross sleepers are, under all circumstances, preferable to longitudinals.

The plan upon which this line was first proposed to be constructed was, to build the framing of the longitudinal bearers on the tops of twelve feet piles, ten inches in diameter, driven home into the ground. These piles were tied together by transoms, or cross ties. It was supposed by the engineer that this plan would be a cure for the unequal subsidence of the ground in cuttings or embankments, and that the line would always maintain a uniform and steady character, and be independent of the retreat of the ground from under the longitudinal bearers. He imagined that the longitudinals, 15 inches by 7, resting upon piles 15 feet apart, with about 45 lb. rails screwed upon them, would have been sufficient, in case the ground sunk, to support the trains, drawn by engines of 23 or 24 tons, without bending. The first portion, however, that was opened—that is from Paddington to Maidenhead—proved the unsoundness of these views, and excited the surprise of almost all that a man so acute as Mr. Brunel should have fallen into so obvious an error. Had Mr. Brunel taken the very opposite course, and fastened down his longitudinals firmly to the ground, with pins or short piles, he would have had reason on his side, whatever practice may have afterwards proved, because the tighter one thing is confined to another, the less their touching surfaces wear, and the closer a piece of timber is fastened to the ground, the less the ground under it will be affected by any weight going over it, for it is well known that the effect of the impact, or pressure, of one body on the undermost, is somewhat inversely proportional to the weight of the body between them; and tight fastenings of inflexible bodies are nearly tantamount to great weight.

It is, however, to be acknowledged, that after experience had decided against his principles, he readily abandoned them, and adopted the old plan, which has succeeded better. The question of the Great Western construction is now, therefore, narrowed into that of superiority between a 7 feet and a 4 feet 8½ inch gauge, and between continuous and non-continuous bearers. But to return to the engines.

After some delay, I obtained the order of the Board for going over their line, and started on Friday, December 17, 1841. I took the *Panther* engine to Maidenhead, 7 feet wheels, 18 inch stroke, and 15 inch cylinder. She is said to consume 27 cwt. of coke in 80 miles, or 37¾ lbs. per mile. She had been running for 16 months; her wheels, as most of the other engines on the Great Western, *have steel tires*,

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the right of supplying which belongs to Mr. Gooch, or his licensee—the superintendent of the locomotives—who has a patent for them. The *Panther* had outside framings, and out and inside bearings on the driving wheels; she is said to weigh 24 tons, when loaded with her complement of water and coke, and was a good deal out of repair, or as jockeys would call it, groggy, and had some ugly holes in the tires of her wheels, notwithstanding they were made of steel; the motions I observed in her were a pitching and rolling, but not much of the sinuous motion—indeed I observed but little of the sinuous in any of the Great Western engines. The *Panther* had a good deal of longitudinal vibrations, or shocks, and was very rough on the platform in quick motions. This, as all the engines on the Great Western, was a six wheel engine.

While stopping at Maidenhead, I took the following dimensions of this engine, which I understand are very nearly the same for all the Great Western locomotives, the chief difference being in the size of their driving wheels: End of platform to axle of trailing wheels, 2½ feet; to end of fire-box, 3 feet; to axle of driving wheels, 9 feet; to leading wheels, 15 feet 8 inches; to end of smoke-box, 18 feet 5 inch.; to end of framing, 20 feet 5 inches. Thus there is between the trailing wheels and driving wheels, 6½ feet; between the driving and leading wheels, 6 feet 8 inches; and between the trailing and driving, 13 feet 2 inches.

From Maidenhead I took the *Cyclops* engine, which is a much steadier engine, but still with a good deal of longitudinal and side rolling motion, and like the other, very harsh upon the platform. She had 7 feet driving wheels, 18 inch stroke, 15½ inch cylinder, and was said to consume 35 cwt. of coke for 77 miles, or near 51 lbs. per mile. Her daily work is 154 miles, and she had been out from October, 1839.

At Swindon, where the Company intend to have their locomotive establishment, we took on another engine, the *Rocket*, which had only been out the Monday previous. She had 6 feet driving wheels, 18 inch stroke, and 14 inch cylinders. She was built by Stotherd, and was an extremely easy, tight, and lively engine. I observed nothing in her but a small longitudinal motion at high speed, and thought her considerably better than either of the engines I had rode on. Her steam was made in such abundance, that we were obliged to keep the fire-box door almost constantly open.

The next day I started off on the Bristol and Exeter, with the *Firebrand* engine, of the same pattern as the *Panther* and the others, as to bearings. She had longitudinal motion, but not much vertical. She rolled and pitched at fast motions, more, probably, or at least as much, as any four wheeled engine I have been on. She was out of order, and it is said that one of her cylinders was "soft."

I was so dissatisfied with all the engines I had tried, except the *Rocket*, that I applied to a gentleman at Bristol to furnish me with the names of some of their best engines, or to tell me how to distinguish them, for, as I observed to him, those I had been on appeared to be all cripples. After some hesitation, I was informed that all

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their latest and best had brass domes to the fire-boxes. To these brass domes I afterwards paid my chief respects, as nearer the standard of perfection, and avoided the copper, as of a vulgar and homely character.

On Monday I went again down the Bristol and Exeter line, on the *Mars* engine, made by Longridge & Co., and capped with the genuine metal. She had 7 feet wheels, 15 inch cylinder, and 18 inch stroke; was a new engine, and appeared to me to be a very excellent one. She had very little longitudinal, and no vertical, motion, at 50 miles an hour; some rolling, however, was perceptible. She had been out four months, but had had very little work, which may partly account for her easiness and freedom from unpleasant motions. I went down to the Clevedon station on this engine, and returned on the *Lance*, 6 feet wheels, 14 inch cylinder, and 18 inch stroke. This engine always pitched at starting, and for some time after she had more longitudinal motion than *Mars;* was rougher, but did not roll so much. She had been out six months, and had had a good deal of work.

During the time I was at Bristol, I had heard considerable complaints of the curve near the Bristol station on the Exeter Railway, which is of very short radius. They affirm that it strains the framings of the engines very much, and that it was the intention of the engineer to strengthen these framings with an additional plate of iron.

On Tuesday, the 21st, I started again upon the *Wolf*, an engine of Sharpe, Roberts & Co.'s make. She had 6 feet wheels, 14 inch cylinder, and 18 inch stroke, and had been out about six or eight months. I was told she consumed 27 cwt. of coke for 45 miles, or 67 lbs. per mile, and that some of Stotherd's burn only from 22 to 24 lbs. per mile. The pressure upon this engine, as on most others, was about 55 lbs. to the inch. Owing to the load and frost, we did not go more than at the rate of 25 miles per hour. She was a steady, strong engine, but as we traveled at a low speed, and the road was very slippery, I could see but little of her faults, if she had any.

It was on this engine I observed the curious phenomenon of the hoar frost mentioned at page 57 of the present volume.*

I went to Weston-super-mare on her, and returned on the *Castor*, built by Nasmyth, which had 7 feet driving wheels, 15 inch cylinder, and 18 inch stroke. She was said to consume 31 bags, or cwt., of coke for 66 miles, or at the rate of 52½ lbs. per mile. She had been out seven weeks, and was a good steady engine at 49 miles an hour, with the exception of a little longitudinal motion. At low speeds I observed her pitch a trifle, as I had several of the others.

After having returned early from Weston, I went and saw Mr. Brunel's, or Hawthorn's new engine, as they call it. This immense machine is built on two frames, with six wheels each. On one frame was carried the boiler, the fire of which was intended to be blown with a fan, as well as with the blast-pipe. The machinery is carried on another six wheels, but I did not see it, as I found it was at one of the stations near London. Not having the machinery there, I

* Jour. Frank. Inst., vol. iv, p. 77.

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could scarcely make out how they were united, and no one was able or willing to tell me; but it appeared to me that the machinery was to precede the boiler. From what I saw, I should judge the boiler, with the framing and wheels, to weigh from 15 to 17 tons. If the other part is as heavy, this engine would weigh from 30 to 34 tons.

On Wednesday, the 22nd, I started on the *Djerid* for Bath. This engine was one of Stotherd's, and had been out from May. As his others, she had 6 feet wheels, 18 inch stroke, and 14 inch cylinders. She was a good, lively engine, but had longitudinal motion, pitched at starting, and rolled a little. She was said to consume 45 cwt. of coke for 114 miles, or about 44¼ lbs. per mile.

At Bath I stopped, and returned to Bristol by the *Jupiter*, a very powerful engine built by Longridge, apparently 7 feet wheels, and out nine months. We came back at a tremendous rate—I should think, certainly, at not less than sixty miles an hour. The engine rolled about enormously, had a sharp longitudinal, not much vertical, and a little side, motion. I was so glad when I got off this *Jupiter*, from her pitching and rolling about, that I vowed by Jupiter I would never get on her again.

I understand that all the six wheel engines have 14 inch cylinders, and 18 inch stroke. The seven feet have 15 inch cylinders, and the same 18 inch stroke. The goods engines have 5½ feet driving wheels, 15 and 18 inch cylinders, and are generally coupled in four wheels. The goods engines have 96 tubes in the boiler, 8½ feet long, and 1¾ inch diameter. The tube surface is about 238 square feet, and the whole area of the fire-box 83¼ square feet. They are said to work a trifle expansively, and to cut off the steam at about seven-eighths of the stroke, and have three-fourths of an inch lap. But I understand the passenger trains cut off the steam from five-sixths to three-fourths of the stroke.

While at Bristol, I took the following dimensions of the *Castor*, *Hector*, and *Lance*:

Name.	Gauge.						End of Platform.							
	Trailing wheels.		Driving wheels.		Leading wheels.		To hind axle.		Driving.		Leading.		End of sm. box	Length
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	in.	in.
Castor,	6	11.2	6	10.8	6	11	2	5	9	0	15	8	18½	20½
Hector,	6	11.2	6	10.9	6	11.4	2	5	9	0	15	8	18½	20½
Lance,	6	11.0	6	11.0	6	10.8	2	5	9	0	15	8	18½	20½

In most of the Great Western engines, if not in all, there is a partial division in the fire-boxes, within which water is contained, for the purpose of increasing the heating surface. I am not sure whether this division runs one way in every engine, I rather think not, and that in some engines it is across the fire-box, and in others longways. No doubt this helps to increase the quantity of steam generated, but to what extent I am not aware, not having the proportional dimen-

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sions of this partition. From being in the middle of the fire, the effect is, probably, considerable. I think I have seen something of the kind in some other engines, but am not quite sure.

I returned home on the 25th, the day of the lamentable accident at the Sonning cutting; but, it being night, I did not get upon either of the engines.

On 30th December, I went upon the *Gorgon* engine, which had been out three or four weeks. She was a strong, powerful engine; had very little sinuous motion, but she had longitudinal at 30 miles an hour, and was inclined to pitch and roll a trifle. Her wheels were 7 feet, 15½ inch cylinders, 18 inch stroke. I was informed she consumed 50 bags of coke to Swindon and back, a distance of 154 miles, or 36½ lbs. to the mile.

I left this engine at Maidenhead, and took the *Leopard* to Reading, a sluggish but steady engine, said to consume 60 cwt. of coke for the 154 miles, or near 43½ lbs. to the mile. She had been out 19 months.

I returned on the *Comet*, which had been out four months. She appeared to roll more than the last, and was nothing near so steady.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

(Continued from Vol. IV, page 247.)

"The Slip" on the Croydon Railway.

Lecture IX. Jan. 11, 1842.—According to appointment, this lecture was delivered at the great slip near New Cross, on the Croydon and Brighton Railways. The motive of this visit was to explain to the class the reason of, and to point out the means which might have been taken to have prevented, the great slip which occurred there recently. On leaving the train, the Professor led the way to the spot, which is situated about half a mile from New Cross. The length of the slip is very considerable, the depth of the cutting very great, and the mass of earth that has slipped down from the top of the bank is of an imposing appearance. The appearance of the slip is as usual—perpendicular at the top for some depth, and then bulging out near the centre; a great number of laborers are employed in shifting the immense quantity of earth to be removed, in consequence of the slip, which is estimated at many thousands of yards. In the meantime, a convenient covered walk has been made for the passengers to pass from one train to another. On both sides of this cutting, for some distance along the line, slips have taken place; but on the left-hand side going from London, they are of but little importance, compared with the one that was to be particularly inspected by the class. The soil consists of the plastic clay, with numerous strata of sand and gravel, the clay itself being very binding, but being, from the recurrence of these strata of sand and gravel, very liable to the infiltration of water; and, consequently, to slip, when the up-drainage is not particularly attended to, and the most constant attention paid to every

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symptom of a slip being about to take place. The Professor then pointed out what he considered to have been the occasion of all the mischief. Nearly all along the slip the earth had given way at the side of a top drain, parallel with the railway, and in some places it was so apparent, that the declivity looked as if made purposely; this had invariably occurred where there were cross drains from the neighboring ground, (which is considerably elevated,) leading into the main drain along the top of the cutting, and which, not being puddled, or made water-tight, had allowed the water gradually, and during many months, to insinuate itself into the veins in the clay, and had at length forced the mass out as it appeared. He then stated, as his firm opinion, that the slip ought never to have taken place; the earth having stood for three years, was a sufficient proof that the slope was correctly laid out; and, finally, it could only have been by subsequent natural causes that the accident occurred, while, if the precaution of preventing the drainage from the upper fields getting into the body of the slope had been attended to in time, it might have prevented the slip, and it was obvious that the great evil—water—had been gradually insinuating itself into the bank a long time before. In another part of the cutting, he pointed out a place where a slip was expected to take place in the slope; but he disapproved of what had been done by way of precaution, and explained that any operation of making cuts or vertical holes in the slopes, which would admit water, ought to be avoided by all means in the engineer's power, instead of being encouraged. The apertures should be driven in horizontally, and brushwood drains introduced, or a kind of hurdle or *fascines*, which would act as a drain, and be extremely efficacious; on this principle he strongly objected to the cutting of slight surface drains on the slopes, as he thought them worse than useless, being more likely to admit the water than to drain it off. He alluded to a curious circumstance which had occurred a little higher up the line, where the railroad was made in what used to be the bed of the canal. It appeared that there was a spring, and the water, instead of finding its way out of the slopes, actually raised up the rails. Several other points of interest were then examined.

Lecture X.—Wednesday, the 19th Jan., Professor Vignoles delivered his tenth lecture "On Civil Engineering," on the West London Railway, at Wormwood Scrubbs. This was rather a practical illustration, by way of experiment, than a lecture—it being a practical exemplification of the working of the system of locomotion by means of atmospheric pressure, effected by the peculiar valve invented by Messrs. Clegg and Samuda. In addition to the ordinary class, which was fully attended, there was a large assemblage of scientific men, including several of the engineers of the Belgian railways, and officers of the corps of Royal Engineers; Mr. James Pim, and many of the principal proprietors of the Dublin and Kingstown Railway; Col. Jones, Col. Alderson, Major Matson, Mr. Woodhouse, Captain W. Moorsom, and several other engineers.

Second Course.—On Wednesday, the 9th Feb., Professor Vignoles delivered his introductory lecture to the second course of lectures.

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He stated that, having, in his first course of lectures, touched upon several of what he might call the cardinal points of civil engineering, he was then about to enter the second course, for which (according to previously concerted arrangements) one only of the numerous branches of this profession had been selected as the theme, with a view of entering considerably into its details, rather than to discuss in a more general manner a variety of subjects, which, though perhaps equally important, equally interesting and useful, and equally necessary for the student, could not be thoroughly investigated in the course of a single session. In the introductory lecture he would, however, touch concisely on the wide topic of the internal communications of civilized countries, as falling within the scope of the theories and practice of a civil engineer, treating them here as on a general theme; but the subsequent discourses to the class would consist of the details of that more modern branch of internal communication, of so much interest in the present day—the railway system. It had been well and truly remarked by an enlightened observer, that the great characteristic feature of the present age was the appreciation of the value of time. In an eloquent introduction to a pamphlet on one branch of internal communication, the author expressed himself in terms which he was tempted to quote, as an appropriate preliminary to his own remarks:—"In that career of improvement which has distinguished the last thirty years beyond, perhaps, any previous history of the world, and in which the sum of the vast ameliorations effected, in all that relates to the condition of man, is not less striking than the rapidity with which their details have followed upon each other, one important lesson seems to have been in an especial degree impressed upon those engaged in the pursuits of industry, and upon the commercial and manufacturing classes in particular—they have been effectually taught to appreciate the value of time, and to apply to its use a degree of rigid and judicious economy, of which the past affords no example; a lesson which is daily illustrated by the vast expenditure, in this country, upon works affording facilities in accelerating intercourse, since it is universally felt that distances are virtually shortened in the precise ratio in which the time occupied in traveling them is abridged." And it is the practical application of this axiom, which it is almost peculiarly the lot of the civil engineer to be called on by the statesman and the capitalist to realize. In looking back through the vista of centuries, and endeavoring to pierce the mist of tradition, we are led to conclude that the formation of roads must have been amongst the earliest rudiments of civilization; but until science, or, at least, until system, was applied to their construction, it is evident (from the traces of the simple paths of comparatively modern times, and of no remote countries,) that the merest tracks sufficed to satisfy our ancestors, who had not yet learned the "value of time." Little more was then required than a path upon naturally firm earth —all marshy grounds were avoided—the fords of the rivers were alone resorted to—and the irregularities of surface, or inclination of the road, or its circuitous course, were of little consequence to the pedestrian, or even to the mounted traveller, when man had learned

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to subdue the horse to his wants and wishes. The path generally traced from one distant wigwam to another became the track from village to village, and at length served as the road from town to town, or even to the capital. The line once traced out, indolence and habit seem to have prevented any great exertion to improve or repair, beyond what was indispensably necessary, even after the invention of wheeled carriages; and the system of following the ancient course of roads seems to have been pertinaciously adhered to in all countries until the advance of civilization, and the wants of the community, produced improvement, and gave rise to the calling of the road-maker, and ultimately to the profession of the engineer. The first exercise of his art—for it did not reach the dignity of a science until within very modern times—was, probably, in the formation of raised roads, or causeways, to strong holds, dwellings, or cities, accidentally or artificially made liable to inundations; and of this kind were the approaches to the passage of the River of Babylon, which the fables of antiquity magnified into a bridge, as long, and consisting of as many arches, as that in the celebrated vision of the Arabian sage. The first step towards internal communications being roads, it may be well defined as the first step in true civilization, and the Abbe Reynal has justly remarked—"Let us travel over all the countries of the earth, and wherever we shall find no facility of trading from a city to a town, and from a village to a hamlet, we may pronounce the people to be barbarians, and we shall only be deceived respecting the degree of barbarism."

By this test we should probably be induced to judge of the Chinese, if their water communications did not, to a certain extent, supply the absolute want of anything like a road capable of passing a loaded wheeled carriage even at the gates of Pekin. Of all the people in the world, perhaps the Romans took the most pains in forming their roads, and vast was the labor and expense bestowed to make them spacious, firm, solid, and smooth—roads, in fact, from two to even ten or twelve feet thick, formed of what we call in these days "concrete;" but, as regards the system of laying out, in the modern engineering sense, they do not appear to have had the slightest idea. Straightness of direction seems to have been their only character, and, with a lofty disdain of the effects of gravity, their grand military routes, excepting near Rome itself, were carried direct over hill and dale. Thirty roads, of an aggregate length of over 50,000 miles, radiated from their magnificent capital, in Italy, to the furthest extremity of their almost boundless empire; they only served as internal communications, for keeping down, by their legions, the rebellious spirits of the Briton, the Hun, the Greek, or the Persian, who had, in succession, bowed to the Roman yoke—yet, as monuments of the highest degree of art and civilization of those ages, must they be admired by all, and may be usefully studied by the engineer of the present day, few of whose constructions, even the gigantic railway, will probably endure as some of the Roman roads have done—such as the Appian Way, for instance—through the long period of nearly two thousand years. The number and extent of these roads, made by the first

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conquerors of Albion, through this island, have only been ascertained and appreciated since the publication of the magnificent maps of the Ordnance Survey by the corps of Royal Engineers, by those who have studied their beautiful and surprising accuracy, and their minute topographical details, which enable a curious inquirer to trace, by their remarkable straightness of course, these ancient routes, through woods and remote districts, and over wide ranges of hills, where their origin, even in tradition, is now forgotten, and where the long lane, grassed over and forsaken, from its steepness or seclusion, accurately laid down, in its true course, by the science of the present day, marks, at intervals, over whole counties, the former line of the stately march of the Roman soldier. But it remains at this day an unsolved problem in engineering, to discover by what means these roads were laid out in such perfect truth of direction, through the thick and trackless forests which then covered the whole island. It has been observed, that it is one of the most difficult points for a political economist to define, with any degree of certainty, the line of demarcation between public and private enterprise, in the execution of works of internal improvement. In a former lecture, he observed that it was undoubtedly owing to the establishment in France, by Richelieu, of the Board of Roads and Bridges, that that country was in possession of excellent roads long before the principal part of Europe; he might have added, also, canals—at least, before we had them in Great Britain; and yet have a good reason to believe that, at the present time, that very establishment is a serious obstacle in retarding the introduction into France of the modern system of improvement of internal communications, by paralizing the self-dependence of the districts. In this country, the very opposite system, of leaving almost everything to private enterprise and individual exertion, has been most strikingly successful, and has fostered and matured the talent, the ingenuity, the skill, and the experience of the civil engineer, from the competition created by the necessity of individual exertion, which it is presumed would not have been developed, had he been a government dependent. The origin of the system of forming and repairing roads by trustees, and the collection of tolls for that purpose at turnpike gates, dates somewhat more than a century back, and the rapid improvement of our internal communications, both by land and water, about that time; and it is a remarkable fact, that, when land was of comparatively small value, it was more difficult to obtain ground for a new road than at present, when a square yard of land sometimes costs more than would have purchased a rood in former days; and when one of the public objections seriously urged was, that if so many roads and canals were made, it would diminish the quantity of land required for agricultural purposes! But, happily, general knowledge has been diffused, and the former prejudices have yielded to calculation, as man has acquired a knowledge of the value of time, and has found that the payment of turnpike tolls, for good and level roads, is cheaper than to keep extra horses to drag his teams up steep hills, or through marshy ruts. The Professor next stated, that he should not go into the detail, either of

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the laying out, or the construction, of roads, but he must add a few observations, as connected with the duties of an engineer, in regard to some of the general principles. He should accommodate a new line of road to local circumstances, so far as could be without superseding public advantages. It would be ridiculous to follow the old Roman fashion, on the mathematical axiom that a straight line is the shortest that can be drawn between two points. This would not make the most commodious road—hills must be avoided, towns must be resorted to, and the sudden bends of rivers must be shunned. It is not suggested that roads should be made serpentine, merely for the sake of the picturesque; but the skill of the engineer is to be exerted in avoiding irregularities of ground and irregularity of inclinations, and he will generally find, that a strict adherence to a straight line is of much less consequence than is usually supposed, even in actual distance over long lengths. It was well known that a blind man was, some years ago, advantageously employed, through Yorkshire and Derbyshire, in laying out roads through those hilly counties. He followed the streams which made their way amongst the hills, and, by finding out the chords of such arcs, or bends of the river, as passed on practicable ground, he succeeded in his attempts. It is obvious that, when the arc described by a road going over a hill is greater than that described by going round it, the circuit is preferable; but it is not known to the ordinary road surveyor, though it ought to be ingrafted in the mind of the engineering student, that, within certain limits, it would be less laborious to go round the hill, though the circuit be much greater than that which would be made in crossing it. Thus, when a hill has an ascent of no more than one foot in thirty, the thirtieth part of the whole weight of the carriage, of the load, and of the horses, must be lifted up, whilst they advance thirty feet. In doing this, one thirtieth part of the whole load continually resists the horses' draught; and thus, in drawing a wagon of six tons weight, a power to overcome resistance equal to the force of two additional horses must be exerted. But what is here said of level roads must not be strained into an assertion that a perfectly level road is always the best for every description of draught or load. Alternations of rising and level, or of falling ground, are serviceable to horses moving very swiftly; the horse has time to rest his lungs and different muscles, and of this the experienced driver knows how to take advantage; but while this qualification is made, care must be taken not to strain it too much, as did one provincial road maker, who very ingeniously carved a naturally quite level road into a series of short billowy undulations, which his successor had to level again. Without traveling through the whole history of road improvements, he might state that Telford in England and Scotland, and, in Ireland, Nimmo, Griffiths, and Edgeworth, brought the laying out and construction of roads to the present perfection; and of the writings of the latter he had availed himself in many of the preceding observations. The many roads of Great Britain were just arrived at almost the highest degree of perfection, when again the increased appreciation of the value of time led speculators to conceive, and our engineers to realize, the idea of

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the employment of iron surfaces for roads. Before, however, following the gradual transit of roads into railways, he would make a few observations on the other branch of international communication—the navigable river and the canal.

(To be continued.)

Franklin Institute.

Extracts from the Reports of the Judges appointed to examine the Articles offered at the Twelfth Exhibition of American Manufactures, held in Philadelphia, from the 18*th to the* 31*st day of October*, 1842, *by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.*

[CONTINUED FROM VOL. IV. PAGE 351.]

Report on Cotton Goods.

In compliance with the request of the Franklin Institute, the Committee on Cotton Goods have carefully examined the several samples submitted to their inspection, and respectfully report as follows:

No. 5, Bleached Cotton Yarn, spun by Walton & Mercilliott, possesses the qualities of evenness and strength. As none of your committee are manufacturers, they are not so intimately acquainted with the article, nor so competent to judge of its qualities, as those who are accustomed to work in it; they, however, are of opinion that it is very good.

No. 20, Turkey Red Yarn. The foregoing observations in reference to the yarn, independent of the color, apply in this case. So far as the color could be judged of by sight, it is very good, and apparently fast. Permanency of color in this article is very important. At the solicitation of the manufacturer, a sample has been handed to a gentleman skilled in chemistry, for the purpose of having its qualities more fully tested. The result of his examination has not been communicated to the committee.

No. 21, Cotton and Worsted Net Suspenders, manufactured by Thomas Poole. The web is exceedingly smooth and regular, and possesses in an unusual degree the essential qualities of strength and elasticity.

No. 44, Ginghams, manufactured by Sharp, Lindsay & Haines—imitation of the imported Manchester gingham. An excellent and well-made article.—Checks, from the same, also well made and durable; the yarn of clear dye and handsome bleach.

No. 92, 4-4 Fancy Plaid Ginghams, manufactured by B. Sharkey, bear a close resemblance to the imported Earlston gingham; are woven with exceeding regularity, of excellent and striking style. These goods are superior to anything of the kind, of domestic origin, that has come under the notice of the committee. They are of opinion that their value and beauty would be enhanced by a harder finish.

No. 152, Pantaloon Stuffs, manufactured by Joseph Ripka; ab-

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though devoid of novelty, fully sustain the excellent character that similar descriptions, emanating from the same source, have so long enjoyed. The consumption of these goods is very great; they have, to a considerable extent, supplanted the imported.

No. 263, Cotton and Worsted Damask Table Covers and Curtains, manufactured by R. Garsed & Brother; a new article in our manufactures, which promises successful competition with the imported, and merits a premium.

No. 611, Fancy Cotton Hdkfs., made by James Schouler. A fair style of printed hdkfs., resembling the imported.

No. 769, Cotton Lacings, manufactured by Ezra J. Cady; strong and well made, and, if applied to a new and useful purpose, would be commendable, and worthy of encouragement.

No. —, Power Loom Ginghams and Checks, manufactured by J. C. Kempton. A well made and substantial article, of bright colors, and good patterns; meritorious on account of being woven by power looms.

Of Prints, there is a rich and choice variety, manifesting great improvement. From J. Dunnell & Co., Philip Allen & Son, Perkins & Wendell, and the Merrimack and American Works, are exhibited samples of excellent style, and superior execution and coloring. Your committee are decidedly of opinion that Perkins & Wendell are entitled to the premium for superiority of execution, particularly of the light ground London style, and black ground Hibernia chintz, which surpass any that has come within their observation. Their three colored stripes, and rich green ground stripes, are also very superior; in fact, the whole of the samples from this factory merit high commendation.

There is a vast consumption of printed cottons, and the domestic article is so excellent and cheap, as almost to exclude foreign fabrics, which, but a few years since, furnished the whole supply. The advancement in this branch of cotton manufactures has been great and rapid.

Of Bleached Cottons, there are samples from the Union, Bartlett, Lonsdale, and Hamilton mills, and from Messrs. Harkness & Stead, which well sustain the high character this description of goods has acquired. The 10-4 bleached sheeting from the Phœnix Company is of superior quality.

There are samples of ticks from Nathaniel Clegg and Robert Whitaker; plain and printed natural colored yellow nankeens, from Lonsdale Company; ginghams and checks from James Rowe; colored cambrics, canton flannels, all well manufactured. We have been so long familiar with excellent goods of these descriptions, that they have lost the attraction of novelty.

Your committee believe that they have noticed all the articles exhibited in their department, and, in closing, would remark, that the exhibition of cotton goods is not very extensive, nor is it marked by many novelties; but there is strong evidence of a steady and certain advance in this branch of manufactures. In the finer and lighter fabrics, as yet, little has been done; this, it is conceived, is not owing to

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the want of skill and enterprise, but rather to the fact of much manual labor being required in their production, which cannot be obtained for so low a price as in Europe. This cause will probably retard, if not prevent, the growth of this description of manufactures. The amount of domestic cotton goods consumed in the United States is immense, and the importance of this branch of manufactures is immeasurably increased from the circumstance, that the whole of the raw material employed is of native growth. This will strengthen in union the two extremes of the country, by making their interests one.

Letter from Dr. A. D. Chaloner, accompanying the above Report.

To the Judges on Cotton Goods.

GENTLEMEN: Agreeably to your request, I have submitted the specimens of "Turkey red yarn," *American* and *foreign*, to the action of various powerful chemical agents, without entirely extracting the coloring matter from either.

1. The specimen marked (A) was boiled for twenty minutes in a mixture of *sulphuric acid* and water, two drachms (f℥ij) of the acid to two ounces of water.

2. The one marked B, for a similar space of time, in a strong solution of *caustic potassa,* a powerful alkali.

3. The third, marked C, was immersed in a solution of chlorine, which did not remove it; but when placed in chlorous acid, the *original red color* was then, in both specimens, removed, and the yarn became of a *lemon tint.*

Conclusion.—The American specimen stood the chemical agents *equally well with the foreign:*

The *acid solution* [A] having acted on both equally, slightly brightening it.

The *caustic potassa* [B] turned *both* specimens to a *maroon color.*

The chlorine solution *deepened* the color, but the chlorous acid removed the color from *both* specimens, and left the yarn of a lemon tint.

The foreign specimen was furnished by Mr. D. S. Brown, and was remarkably fine.

The American was taken from the *interior* of the package in the exhibition.

I have been gratified by the results, as redounding to the credit of American manufactures; and, as the specimens have been *equally* affected, it is fair to conclude that the *coloring matter* is similar, and that a *brighter color* may be obtained by further experiments.

The American yarn was made by James Wright, of Philadelphia.

Respectfully, A. D. CHALONER, M. D.

Laboratory of University of Pennsylvania, Oct. 27, 1842.

Report on Hardware and Edge Tools.

The judges appointed to examine the hardware and cutlery, report, that they have discharged the duty assigned them. There were several articles on the invoice, for examination, which the committee

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could not find; they are indicated by the omission of a ✓ to the left of the number.

The quantity and variety of hardware and cutlery was not so great as the committee have seen at former exhibitions; but the specimens exhibited, we are assured, with but few exceptions, are but fair samples of what the manufacturers furnish for their ordinary sales. As a general remark, they all deserve to be pronounced creditable to American skill and ingenuity, and will bear, generally, a fair comparison, in quality and price, with the imported article of the same description. Indeed, some of the specimens—such as scythes, (an article of immense consumption,)—have nearly driven the imported article out of the market. The committee are admonished to be brief, and they now proceed to detail, as concisely as possible, the character of the articles, as per invoice.

No. 43, a case of woven wire for paper makers, made by Joseph M'Creedy, and deposited by him. This article is of excellent make, being of unusual fineness, containing 5184 meshes to the square inch. One piece of this is of extraordinary breadth, woven with great equality, the surface even, and free from twist. The material composing these articles is partly American, and the maker of the articles deposited assures the committee he found it, in strength and ductility, superior to the best imported. Paper makers who have examined these specimens, pronounce them unusually good. The committee recommend that a silver medal be awarded to the maker.

No. 51, a lot of wood screws and rivets, made by L. Goujon & Sons, Philadelphia. These are a well made article, and have found general favor with the mechanics who have used them for several years past; they are superior to the best imported article of the same description, and deserve honorable mention.

No. 56, a case of locks, made by Conrad Liebrich, Philadelphia. These appear to be well made and adapted to general use, and worthy the attention of the public.

No. 60, two cards augers, made by Messrs. Birkinline & Co., Reading. They are very creditable to the makers.

No. 67, a pair of horse cards, made by George Taber, Canton, Ohio. A fair article for the use intended.

No. 80, a double barrel rifle, made by Spang & Wallace, Philadelphia. This article is well made, and in all respects highly finished, and extremely creditable to the makers.

No. 81, a steel box coffee mill, made by Adam Pritz, Philadelphia. This is a decidedly good article.

No. 109, six scythes, made by O. Hunt & Brothers, East Douglass, Mass. These are well made, and worthy the attention of the trade. From the perfection which this branch of American industry has attained in quality and price, the foreign article is nearly excluded from our market.

No. 113, a patent wrench, made by the Canton Hardware Co., Mass. A well made article, and adapted to ordinary use.

No. 124, a card files and rasps, by George Machen, Philadelphia. The rasps are remarkably well made, and will bear a comparison, in

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all respects, with the best imported article. The files are good, and give promise that, with encouragement, the maker will soon rival the best specimens of European make. Considering the importance of this article, and the excellence of the specimens exhibited, the committee think the maker is fairly entitled to a premium. There were some persons who doubted these being American make, but the committee received satisfactory evidence that they were really made here,

No. 135, two rifles, by Wm. Robinson, Philadelphia. These are also beautiful specimens of American manufactures, and reflect great credit upon the taste and skill of the maker.

No. 141, five saws for cutting iron, by Jonathan Paul, Philadelphia. A fair article, and appear well adapted to the purpose.

No. 165, a double barrel gun, by William Robinson, Philadelphia. Well made, and finished in excellent style—worthy the attention of the public.

No. 181, six coffee mills, by J. Rittenhouse, Germantown. The committee were highly gratified with the appearance of these articles; considering their use, they are really a splendid article.

No. 187, one dozen files, by Thos. P. Erwin, Philadelphia. These are a good attempt at the manufacture of this important article—they are, however, not eqnal to No. 124.

No. 194, a pattern card of hardware, by different makers, deposited by Livingston & Lyman. Beautifully finished, and highly creditable to the makers.

No. 203, a card of comb plates, by Andrew Tracey, Poughkeepsie, N. Y. So far as the committee could judge, there is nothing very remarkable in these specimens.

No. 213, a latch, by Wm. Bray, Philadelphia. Nothing superior.

No. 225, two swords, by F. W. Widman, Philadelphia. The mounting creditable—the committee are not informed whether the blades are American manufacture.

No. 231, machine made horse shoes, by Thomas M'Devitt, Philadelphia. Well made for ordinary use. The committee are unable to say how they compare in use with those that are hand wrought.

No. 243, a case of tailors' and bankers' shears, by R. H. Heinish, Newark, N. J. These are a very superior article. The committee think that, for ordinary use, whether the form, finish, or quality is considered, they cannot be surpassed. They reflect great credit on this branch of American industry—are worthy, in all respects, the attention of the trade for whose use they are designed—and are fully entitled to a premium.

No. 247, a card brass and plated hinges, by G. W. Bradfield, Philadelphia. These are very creditable to the maker—they might be improved by making the joints of some of the specimens tighter.

No. 249, two locks, by James Bradfield, Philadelphia. A fair article for ordinary use.

No. 253, a bolt mortise lock, by Wm. Todd, Philadelphia. The same remarks are applicable to these.

No. 283, a case of guns, by John Krider, Philadelphia. These are

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splendidly made, and show the perfection which this branch of our manufactures has attained.

No. 284, two cases pistols, by John Krider, Philadelphia. These are also highly creditable to the maker.

No. 295, two cases pen and pocket knives, by Bradley & Beecher, Philadelphia. These specimens, from the quantity, variety, and quality exhibited, were highly gratifying to the committee. They are comparatively a new article to which the attention of American skill and industry has been directed, and though, in some particulars, they may lack the fine touches which the long practice and experience of European makers enable them to impart to their finest quality of cutlery, these specimens give full assurance that, very soon, this description of cutlery will be made in all respects equal to any furnished by the most experienced and celebrated foreign manufacturers. The committee are assured that the article exhibited is furnished to the merchant at nearly one-third less than the same description of European goods can be imported for. The committee would not do justice to the makers, or their own feelings, if they did not recommend a silver medal to be awarded to the manufacturers.

No. 298, six planes, by Luther Fox, Amherst, Mass. These are very good, and worthy the attention of the trade.

No. 310, two cards wood furniture knobs, made by A. Robinson, deposited by maker. These are a good article, and merit the attention of the trade.

No. 324, a case of miniature knives, by Wm. R. Greble, Philadelphia. These specimens are more remarkable for the patience exhibited by the maker, than for the fineness of the finish.

No. 339, a card of tools, by H. Disston, Philadelphia. These are well finished specimens of what the maker can produce.

No. 345, a variety of samples of hardware and cutlery, by "divers persons." The specimens deposited under this number, taken as a whole, are the best in the exhibition. The taste and finish are excellent, and prove the makers to be among the first in their line of American manufacturers. The samples of screws exhibited may be pronounced perfect—the committee have never seen any thing of the best European manufacture that in excellence approaches them. They are in all respects worthy of a premium.

No. 345, three circular saws, by Charles Johnson, Philadelphia, deposited by Curtis & Hand. These are very well made, highly creditable to the maker, and sustain the reputation with the trade which this manufacturer has so fairly earned.

No. 345, three bundles brass wire, by R. D. Johnson & Co., Waterbury, Conn., deposited by Curtis & Hand, Philadelphia. The material composing this wire is very good; the wire appears to be perfectly round, of uniform thickness, and the surface uncommonly smooth—very important qualities in this article. These specimens are highly creditable to the makers, and well worthy the notice of the trade.

No. 345, two bundles of fine iron wire, made by Rodenbaugh, Stewart & Co., South Easton, Pa., deposited by Curtis & Hand; and also

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a sample of very fine iron wire, by the same makers, deposited by Livingston & Lyman. These specimens are very superior articles, and reflect the highest credit upon the makers, especially the *finest* wire. Both samples are round, well polished in the drawing, of uniform thickness, and extremely pliable and tough. The committee regret that the makers have not furnished them with the character and make of the material of which this wire is made. Considering the importance of this article, and the excellence of these specimens, the committee think the makers at least entitled to honorable mention of the Institute.

No. ——, samples brass wire, made by Benedict & Burnham, Waterbury, Conn. These will compare, in all respects, with sample No. 345.

No. 345, one sheet brass, made by the Wolcotteville Brass Co., Wolcotteville, Ct., deposited by Curtis & Hand. The committee have no hesitation in pronouncing this a decidedly good article, being ductile, entirely free from scales, and of good even surface. We understand that this article is in high repute among our mechanics who have used it.

No. 345, knobs, latches and castors, by Blake & Bros., New Haven, Ct. A well known article, and in fair repute by the trade.

There are a variety of locks which the committee examined, but could not learn who are the makers or depositors. They appear to be simple, work smoothly, and adapted to the purposes intended.

No. 383, seven gun locks, by Joseph Lingard, Philadelphia. These are well made.

No. 411, a rat trap, of wire, by E. Oliver, Philadelphia. To be tested only by use.

No. 412, a lot of machine cards, by James Smith & Co., Philadelphia, appear to be well made.

No. 414, samples of pins, by Howe Manufacturing Co., Birmingham, Conn. These are highly creditable to American ingenuity, considering that the manufacture of this article is yet in its infancy. They would be improved if the heads were made fuller and smoother, and the shanks stiffer. They are worthy of encouragement, and deserve the favorable notice of the Institute.

No. 428, a pair of pistols, by Wm. Robinson, Philadelphia. These are highly creditable to the maker.

No. 482, eccentric door springs, by F. Richardson, Philadelphia. These deserve attention—they are beautifully made, well adapted to the purpose, and reflect great credit on the skill of the maker.

No. 484, a lot of planes, by David Colton, Philadelphia. A fair article for ordinary use.

No. 494, a lot of planes, by E. W. Carpenter, Philadelphia. Equal in quality to No. 484.

No. 510, specimens of iron butt hinges and forks, by W. H. Carr, Philadelphia. The forks may be pronounced a good, serviceable article—the butt hinges deserve a more particular notice. All the parts of this hinge are cast together, and, from the peculiar manner in which the joint is formed, greater strength, and, of course, durability, is imparted to the article, than can be obtained by the ordinary mode of

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constructing them. The committee are assured that, notwithstandin the little experience which the manufacturers have had in making this article, that they are even now enabled to furnish an article to the trade which combines greater strength and durability than the European article, at twenty per cent. less than the best foreign article intended for the same use, can now be imported for. When the immense importation of this article is taken into consideration, any process that can cheapen and improve the article ought, as we are sure it will, receive the encouragement of the Institute.

No. 530, samples of machine cards, by Sellers & Pennock, Philadelphia, deposited by makers. The manufactures of this old established house are well known and appreciated by the trade. These samples require no commendation.'

No. 554, four bundles annealed iron wire, assorted sizes, made by J. Washburn, Worcester, Mass.; deposited by Steinmetz & Justice. These are a well made article, possessing evenness, durability, and strength—important requisites in the character of the article. When the immense consumption of this article is considered, the Institute will need no argument from the committee to give to these samples all the credit they so justly merit. It is to be regretted that the character of the iron from which these specimens of wire have been made, was not furnished to the Institute.

No. 554, two rolls platers' brass, made by Benedict & Burnham, Waterbury, Conn.; deposited by Steinmetz & Justice. These are indeed a good article, and extremely creditable to the makers. The surface is very good, free from scales and other defects, of great evenness, ductile and tough.

No. —, lever locks, by G. N. Colcord & Co., Philadelphia. These are good specimens of the makers' skill, and deserving the attention of the trade, to whose notice they are specially commended.

No. 599, a case of carpenters' tools, by H. Chapin, Philadelphia. These are beautiful specimens of what American skill can produce, and deserve the very favorable notice of the Institute.

No. 563, a double barrel gun, by Wm. Robinson, Philadelphia. This is another beautiful specimen of the excellence of American workmanship and taste.

No. 733, smoothing irons, by Savery & Co., Philadelphia. These are well made, and cannot fail to command the attention of the trade. They are, however, but fair specimens of what the manufacturers furnish for their regular sales.

No. 554, a case of four screw wrenches, by H. W. Miller, Worcester, Mass. It is difficult to conceive how a finer article of this description of tools can be made. They are extremely creditable to the maker.

No. 538, an elliptic spring, by T. Rowland & Bros., Philadelphia. This article is believed to be superior to any thing of the kind ever exhibited—it is remarkably well made and finished, and is highly honorable to the character of the manufacturer, and deserving honorable notice from the Institute.

No. —, a case tailors' shears, by Leonard & Wendt. These spe-

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imens of American cutlery are beautifully polished, and are highly creditable to the maker; they, however, lack the accuracy and excellence of No. 243.

No. 702, a card of knives and forks, by G. & D. N. Ropes, Maine. It is with pleasure that the committee call the attention of the Institute to these articles. They form so important an item of our annual imports, that every encouragement ought to be given to establish the manufacture of them at home. These samples are good, and will bear a full comparison with the same description of foreign make. They deserve at least the honorable mention of the Institute.

No. 447, three pocket knives and one case razors, by Samuel Jackson, Baltimore. These are well made articles, and evince excellent taste and skill by the maker. The razors are a very close and successful imitation of the same description of European make. They are all, at least, entitled to the honorable mention of the Institute.

No. 668, smoothing irons, by James C. Adams, Wilmington, Del. This article is also good, and will bear a fair comparison with No. 733.

No. 83, a case of shuttles, by E. G. & R. O. Tripp, Trenton. Very well made.

No. 746, tinned, iron, and copper rivets, by Holmes & Co., Mass. These are, in appearance, decidedly good, and preferred by those who use such articles to any of the imported; they are reputed to be tough and malleable.

No. 322, seal press, by Charles Evans, Philadelphia. This is plainly, but well made, and a good article for the purposes intended.

No. 848, rifle and pistols, by Tryon, Son & Co., Philadelphia. These articles are remarkably well made in every respect, and show the uncommon excellence to which the manufacture has attained in this article.

No. 627, two cards files, re-cut by machine, by Levi Anderson, Philadelphia. After a careful examination, the committee could not but conclude these specimens to be inferior to any of the others exhibited.

No. 759, a card dentist files, by R. T. Murphy, Philadelphia. Very well made, and closely approaching the best English makers.

No. ——, a box machine made horse shoe nails, by Haywood & Sturdevant, Plympton, Mass. These appear to be a first rate article, being well formed, sound, and extremely ductile, and worthy the honorable notice of the Institute.

No. ——, a box cut clout nails, by A. Field, Taunton, Mass. So far as the committee can judge, they appear to possess, in a high degree, the property of the wrought nail, and will doubtless be a good and cheap substitute for many purposes for which the wrought clout has been heretofore used.

No. 845, a card brass cocks, by B. Homer, Philadelphia. These are highly finished specimens of the maker's skill.

No. 607, axes, from the Taunton Co., D. Simmons, and Green & Co. These are really beautiful, and highly creditable to the makers. This article our own manufacturers have brought to such perfection, that the foreign article is entirely forgotten.

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No. 600, one card glass knobs, by A. & E. Baldwin, Philadelphia. These are beautiful specimens of that article, and creditable to the taste and skill of the makers.

No. 457, a fire-proof lock, by James Barton, Philadelphia. This is a beautiful specimen of American ingenuity and skill. It appears to be simple and durable in its construction, not likely to become deranged, and well calculated for the purposes designed.

No. ——, two stands door locks and knobs, by Pierpont & Hotchkiss, New Haven, Conn. These locks are simple in their construction, work smoothly, and appear to be durable. All that the committee examined are mortise locks, and possess the peculiarity of being adapted either for a right or left door. The knobs are beautifully made of a mineral substance, and appear to possess all the elements of durability. The locks and knobs are worthy the special notice of the Institute. It ought also to be observed, that the ordinary article furnished by these manufacturers is fully equal to these specimens.

In closing this report, the committee feel constrained to make one general remark respecting all the guns and rifles exhibited, (excepting No. 506,) that this branch of American industry and skill has attained a perfection among us, which cannot be surpassed by the best European workshops.

Report on Silk Goods.

The committee make the following report upon the articles submitted to them:

No. 24, a lot of stocks, neatly got up, and of good workmanship; part of them are made of American satin. Entitled to honorable mention.

No. 34, two lots raw silk, reeled by Wm. Morris Davis, and entitled to honorable mention; being the only parcel brought through the several processes, from the worm to the hank, by the grower.

No. 110, one card colored silk. Exhibiting every variety of color, tastefully arranged.

No. 169, one case sewing silks and floss. High colors, well manufactured.

No. 192, one pair silk stockings. Handsome, very substantial, and creditable to the maker.

No. 207, six cards silk buttons. Well manufactured, and entitled to honorable mention.

No. 344, one card brocade buttons. Got up in handsome style.

No. 351, three cases silk, from Mrs. H. M'Lanahan. Deserving a medal. We respectfully refer to the subjoined statement, which is interesting; and from the knowledge we have of her exertions heretofore in this branch of manufacture, we consider her entitled to great praise.

No. 351, one case silk, by Miss A. E. Storer. This appears to be the handsomest reeled silk exhibited, and entitled to honorable mention.

No. 371, one case stocks. Remarkably neat, and rather superior workmanship; entitled to honorable mention.

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No. 401, one piece American satin, made at Economy—the only piece of silk goods referred to the committee. It is creditable to the manufacturer, and shows a very satisfactory progress in this branch.

No. 454, one lot silk and worsted hair seating. Believed to be the first of the kind exhibited; if so, entitled to a medal.

No. 555, two pairs raw silk and cotton hose, made by a lady in her eightieth year, and highly creditable to her.

The following articles being deposited too late for competition, were not specially referred to the committee, but they are considered as deserving of notice, viz.:

A case of sewing silks, stockings, and fancy hdkfs., deposited by John Wiltbank. They are handsome specimens of what our country is capable of producing.

A sample of well made sewing silk, manufactured at Auburn prison, State of New York. It is interesting, as a specimen of a new branch of industry in public prisons.

Also, some superior quality of sewing silk, manufactured by the late Philadelphia Silk Company, the discontinuance of which may be considered a public loss.

Letter of Mrs. McLanahan, accompanying the foregoing Report.

To the Judges of Silks, at the Franklin Institute Exhibition.

Gentlemen—It having been suggested to me that an outline of my operations in the silk business, since my commencement, might prove acceptable to you, I cheerfully give the following *brief sketch.*

I took the building which I at present occupy as my filature, No. 32 South Seventh street, and (with many thanks to the gentlemen officers of the Model Filature in Market street, who lent me their machinery,) commenced business in July, 1841, with a cash outlay of five cents.

Having no capital to purchase cocoons, I began, and have continued, thus far, to reel for the owners, either for $1 50, cash, per lb., or one-third of the silk, when reeled, and pay the owners, or growers, $5 00 per lb. for their two-thirds, having pledged myself to keep the price up to them, allowing them also the bounty.

I, however, soon found that foreign silk could be purchased for much less, and that the silk in my hands would not meet with ready sale at five dollars. In this dilemma, I conceived the plan of making it up into sewings, and, as I sold *that,* pay over to the owners their dues. This plan has operated, thus far, well, and (with but one exception) satisfactorily.

In the above manner I have, since my commencement, reeled 365 lbs.; made of sewings for myself and to order, 204 lbs. 09 oz.; sold of sewings, from the single skain to the pound, to the amount of $784.76.

Have reeled for different persons,		72 lbs.
Residents in Philadelphia city,		15
"	Philadelphia county,	3
"	Chester "	14
"	Lancaster "	2
"	Montgomery "	4

Residents in	Delaware county,	4 lbs.
"	Bucks "	6
"	Northampton "	2
"	Columbia "	2
"	Lycoming "	1
"	Northumberl'd "	1
"	New Jersey,	5
"	Delaware,	1
"	Baltimore, Md.	2
"	Washington, D. C.	1
"	Mobile, Ala.	1
"	Port Gibson, Miss.	1

I have now consignments on hand from Enfield, N. C.; Fredericksburg, Va.; Bucks co., Chester co., Northampton co., Lycoming co., Lancaster, and Bristol, Pa.; and from Bolingbroke, Ga.

I have now deposited at the Franklin Institute exhibition, 44 lbs. 6 oz. of reeled silk, and upwards of 30 lbs. sewings.

Very respectfully, H. M'Lanahan.

P. S.—I forgot to mention that my sewings are mostly made for fringes, and, consequently, are rather coarser than for sewing—my customers being principally among the fringe makers. *Not a skain* of it, however, has been made for exhibition, but is what I had on hand, together with twelve pounds of it, made to order for Miss E. Price, of West Chester.

Report on Models and Machinery.

The Committee of Judges upon Models and Machinery having attended to the duties assigned to them, report, that the display of machinery, &c., is much inferior to that of the last exhibition, and that the workmanship, generally, is of a character which indicates a lamentable want of pride, and a great deficiency of enterprise and proper spirit, among the class of machinists. Were an opinion of the state of this branch of the arts to be formed from a comparison between the last and the present exhibition, it would appear that, in place of advancing, it is actually retrograding. This is a humiliating reflection; and we do hope that, at a future exhibition, our mechanics, whose skill cannot be doubted, will show a more praiseworthy pride in their art, and will prove that the spirit of generous emulation is not yet extinct.

No. 6, is a neat model of a row-boat, or yawl, of graceful proportions and good workmanship, by H. E. Chevens.

No. 10, lathe heads and slide rest, made by H. C. Blumner. Of ordinary workmanship and finish.

Nos. 19, 33, 214, and 413; models of stationary steam engines, by various makers, which do not require a special notice.

No. 71, a lathe head with the gearing arranged inside of the pulleys—a compact and neat arrangement, by which the gearing is effectually protected from dirt, &c. Made by Wm. H. Howard.

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No. 83, case of neatly finished shuttles, by E. G. & R. O. Trip, Trenton, N. J.

No. 99, cloth shearing machine, by Parsons & Wilder, Hoosock Falls, N. Y. This machine exhibits an important improvement in the manner of adjusting the distance of the cloth from the shears; this contrivance is simple, and renders the operation of adjustment easy and expeditious. The committee think the invention meritorious, and recommend that a certificate of honorable mention be given to the inventor.

No. 146, a neatly made model of Richardson's hydraulic engine, accompanied by an elaborate and well executed drawing, in isometrical perspective, of the application of this machine in Mr. Mayland's snuff factory. Mr. J. Kutts, architect, is the artist.

No. 174, Fairbank's scales. Similar scales from the same makers have been reported upon at former exhibitions, and are so well known as to need no further notice.

No. 175, model of an important improvement in wool carding machines. The "breast" is dispensed with, and the feeding roller placed close to the large cylinder. A plate, or bar, supported on the frame of the machine, (so as to be adjustable,) extends from side to side in the angle formed by the feed roller and large cylinder, and serves to "break" and distribute the wool. The bar and its application are the basis of a patent. It appears from the certificates of well known manufacturers, that, by means of this improvement, the wool is distributed more equally, and mixtures more perfectly made, and that the quality of the cloth is improved. It has the merit of being very simple, not costly, and can easily be adapted to machines already in use. The committee think the improvement important, and deserving of at least a certificate of honorable mention.

No. 183, lathe and slide rest, by Charles L. Orum. The workmanship, especially of the slide rest, is quite equal, if not superior, to any of the kind in the room, but is not as well finished as lathe work in the last exhibition.

No. 206, improved lathe swivel, by W. C. Grimes. This arrangement would answer very well for small lathes, but is not applicable to heavy work. In many cases, doubtless, it would be exceedingly convenient.

No. 251, hollow mandrel, for turning broom handles, &c. The patent of Mr. Gregg is for the manner of making the cutters, so that they may be easily ground, and for the adjusting plates. The machine is well adapted to the purpose for which it was designed, and appears to do its work very effectually.

No. 252, model of a locomotive. The workmanship indicates considerable skill, but the proportions are not correct.

No. 278, model of a stone-cutting machine. The committee do not know what has been done at the eastward, where machines for this purpose are in operation, and therefore they would suggest that this model be submitted to the Committee on Science and the Arts.

No. 314, a model of a hose carriage, of beautiful workmanship and finish.

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No. 315, a complete working model of a fire engine, by the same maker, Master T. Mason. The workmanship very perfect, and very highly creditable to the maker's skill and taste. The committee think the maker deserving of a certificate of honorable mention.

No. 322, copying press and seal press, by Charles Evans. They appear to be good, serviceable machines. The seal press is extremely simple, and can be made at little cost.

No. 326, a very neat model of a full rigged brig—a piece of workmanship highly creditable to the maker, J. W. Dixon.

No. 337, model of a horizontal steam engine, which, when proportion and workmanship are both considered, is the best miniature steam engine in the room.

No. 338, a well made model of a three ply carpet loom, made by J. Scott. If there is any claim to novelty in this machine, it should be referred to the Committee on Science and the Arts.

No. 352, a very well made model of a compound capstan, by R. C. Taylor. The committee suggest that this be submitted to the Committee on Science and the Arts, as they are not competent to speak of its merits without further investigation.

No. 380, mortising and tenoning machine, made and invented by John M'Clintic. The arrangement of the machine is good, and it works with accuracy and rapidity. It is well worthy of the attention of carpenters and joiners, and cannot fail to be exceedingly useful.

No. 385, neat model of cast iron roofing.

No. 442, gas meters of neat appearance and good workmanship, by Colton & Code.

No. 456, shuttles, of excellent quality and good finish, made by Ellis Jackson.

No. 481, cutting and dividing engine, unfinished. We believe there is no claim for novelty.

No. 511, several slide rests, made by J. H. Schraeder. A very good article, but not highly finished; better have been exhibited at previous exhibitions.

The committee desire to notice the *stocking weaving* machine deposited by John O. Bradford & Co., although it is not on their list. This is an exceedingly ingenious machine, of simple construction, for the purpose of weaving stockings, hose, &c., by power. It is stated that one of these machines will do as much work as three hand machines, and that one person can attend to three or four—a very great saving of labor results. It has been at work during the exhibition, and performs well—samples of its production were shown, which were of excellent quality. This machine was not deposited sufficiently early to compete for a premium, but the judges recommend it strongly to the attention of the Committee on Premiums and Exhibitions, and think it worthy of very favorable notice.

Mr. Calderhead's Carpet Loom.—This machine is the result of the ingenuity and persevering industry of a worthy mechanic, who, under very unfavorable circumstances, has struggled through many difficulties, and produced a machine which, when compared with others for the same purpose, is remarkable for its simplicity. The Committee

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of Science and the Arts have already reported favorably upon it, and have recommended the award of the Scott's legacy premium. This committee would recommend that such further favorable notice of this useful invention be made, as may not be inconsistent with the regulations.

A machine by which the blind are enabled to print for themselves, and thus record their own thoughts, is worthy of especial notice and the warmest commendation. For this simple and ingenious machine we are indebted to Mr. Eisenbrant, of Baltimore. The committee noticed with much pleasure this instrument, which will contribute so much to the enjoyment of those who have been deprived of sight; and they regret that the rules of the exhibition prevent them from recommending such an award as the inventor merits.

Report on Stoves and Grates.

The judges of stoves and grates respectfully report, that the extent of the display is such as to manifest a spirit of enterprise and active competition in this department of manufactures. The variety of cooking stoves is very great, and, as must be expected when ingenuity is taxed for the production of something new, some of its fruits are of a retrograde character in respect to practical usefulness.

Competition in business, and improvements in the art of iron founding, have very much diminished the cost and increased the beauty of stove castings; but it is the opinion of the committee, that, in point of usefulness and durability, none of the cooking stoves now exhibited are superior to some which have received premiums on former occasions.

To none, therefore, can a premium be properly awarded; but honorable mention is due to No. 261, a cooking stove by J. Estlin—No. 438, a salamander, with a very convenient appendage for heating sad-irons—several stoves numbered 487, all of which possess the merit of new and ingenious contrivance, for facilitating their use, or lessening the usual annoyance from the fumes of savory viands—and to a portable boiler and furnace bearing the same number, (487,) which is simple and well contrived. Among the ranges are several which were approved at the last exhibition, and, so far as the committee can learn, have lost nothing of the good opinion then entertained, by two years' trial. Range No. 42 is new in some respects, and possesses merits which, it is believed, entitle it to the silver medal of the Institute. No. 495 deserves honorable mention, and No. 667 is entitled to a similar distinction.

The parlor and hall stoves are numerous and various in pattern and finish; those most worthy of notice, for tasteful proportions and good finish, are Nos. 246, 408, and 420.

Several stoves were entered too late for competition, some of which deserve a passing notice. The air-tight wood stove, No. 524, is neat in its appearance, and affirmed to be very economical in its consumption of fuel.

The self-regulating coal stove for parlors, No. —, is of a remark-

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ably chaste and neat form, and is said to be unequalled in economy of fuel, cleanliness, and comfort.

A radiator stove, No. 541, also entered too late, deserves commendation for good finish and workmanship.

Report on Musical Instruments.

The members of the Committee on Musical Instruments, who accepted the appointment, were Messrs. Kane, Mickley, Peale, R. Patterson, and Ch. Fry. They have had numerous meetings, have subjected all the instruments to full examination and trial, and have sought, by exact and carefully repeated comparisons, to determine the relative merits of such as they judged to be in competition. The conclusions of the committee, they have instructed their chairman to present in the following terms.

The exhibition of pianos was in a high degree creditable. They were, all of them, well made instruments; and the quality of their tone was such, with scarcely an exception, as would attract for them the favorable regard of connoisseurs. On a comparison of average character with those presented at the two last exhibitions, it may be affirmed with safety that there has been a decided general improvement in this elegant and difficult department of the arts. The committee noticed instruments from the manufactories of Messrs. Reichenbach, of Philadelphia, No. 276,—Gale, of New York, No. 521,—C. Meyer, of Philadelphia, Nos. 282 and 246,—and the Philadelphia Manufacturing Co., No. 123, as particularly deserving of praise; and in omitting to recommend the grant of the Institute's medal to either of these candidates, they mean only to imply a want of such a marked superiority of these over other instruments of recognized excellence, as should claim for them such high and special distinction.

The committee also inspected, with much interest and pleasure, the wind instruments which are in the exhibition. They mention, as the two best, an eight keyed flute, by Mr. Weygandt, and one by Mr. Pfaff, of eight keys; the latter remarkable for the sweetness and truth of its upper notes—the former for its fulness and richness in the middle and lower parts of the scale, and for its superior strength of tone. Both are instruments of the highest excellence, and invite special mention on the part of the general committee.

Report on Books and Stationery.

The Committee on Books and Stationery beg leave to report, that they have examined most of the articles on List No. 15.

No. 4, ink from Mr. Brooke.
" 163, " Mr. Bussier.
" 201, " Mr. Rand.
" 286, " Mr. Hoover.
Part of " 485, " Hogan & Thompson.

The black inks of these makers have been tried, and no marked difference was discovered between them; they all flow freely, and are of a good and permanent color.

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The red ink of Hogan & Thompson was of a more permanent and decided color than that of Mr. Hoover, and would be preferred.

Nos. 155, marble ink-stand—191, two books—and 150, a paper weight, were not examined.

No. 433, two Bible biographies, filled with wood-cuts, poorly engraved and worse printed; the exterior covered with gold leaf, laid on without taste or skill.

No. 52, muslin binding, from Bradley, Boston. Nothing particular to recommend it; such work is done here every day.

No. 78, case of binding from Gihon & Co.; want of taste in the designs, and of neatness in the execution.

No. 157, binding from Carle; designed with taste, and executed with skill.

No. 455, bonnet boards, partly made of hay, soft and spongy, but designed to sell low. Also, a beautiful specimen of cloth paper, handsomely glazed, and strong.

No. 391, Robinson's Eagle writing paper. An article well known in the market as among the best—a hand-made paper. Its firmness and solidity enables it to hold its place with many, against the reduced price of machine papers.

No. 163, lot of paper from Magarge's.

Among the cap, writing, and various letter and note papers, Jessup's may be mentioned as the best—an evidence of improvement is discernible.

Some heavy copperplate paper, from Tileston & Hollingsworth, was examined, and certificates from those who have used it, read. There is no longer any occasion to import it (as has been the necessity) from London and Paris; as good an article can now be furnished, and at a much less price. Especial notice should be taken of this, as an improvement within the last few months.

Hubbard's large writing papers, made by machine; beautiful and improved—a better article, and at a lower price, than has heretofore been presented. The *colored papers* from the same manufacturer are entitled to special notice, and more particularly that for lining books, intended to supersede the stained paper, and costing much less.

No. 103. The printing papers from Tileston & Hollingsworth, as also some from Butler, are worthy of special notice, as exhibiting a great improvement in the manufacture, and a reduction in the cost.

The committee embrace this opportunity to congratulate the country on the great improvement that has taken place in the manufacture of paper, and reduction in its cost. It is but a short time since our whole supply of certain fancy, and better kinds of staple, paper, was produced abroad—now, all kinds are made here, equal to imported, and at a less cost.

No. 1, the specimen of types from Johnson & Smith, embrace a greater variety than that from Bruce. The energy and taste of Mr. Johnson are evinced in the novelties constantly added to his office, and the beauty and durability of his types.

No. 218, five blank books, from Leitch. These are good specimens of work in the ruling and binding.

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No. 381, lot of books, bound by Gaskill; among which are some fine specimens of work, having reference not only to taste in the arrangement of tools and design, but in the forwarding, embracing flexible backs, good sewing, &c. The inlaid work is exceedingly neat and elaborate.

No. 435, lot of books, from Lippincott & Co. Some blank books, prepared for ordinary sales and orders, are good specimens of work—the ruling well done, and the exterior of an ordered book neatly and tastefully finished. Some specimens of a prayer book, very neatly bound. An exceedingly neat and well executed edition of Byron is exhibited; it is a commendable specimen of a book—paper, press work, stereotyping, and binding. In relation to this volume, especial notice should be taken of the stereotyping, which was done by Mr. Fagan; for so small a type, it is well executed, distinct, neat, and tasteful. Some specimens of extra binding display great skill in execution, with taste in design.

No. 485, blank books from Hogan & Thompson. Superior work; the sewing is especially worthy of note; the backs are flexible, and open well.

Steel pens, in great variety, and well made; wafers, a superior article; sealing wax, in great variety, and of various qualities. The improvement in these articles is striking, and worthy of note.

No. 285, books from Carey & Hart. The Gift, for 1843, is American in every respect—pictures, engravings, printing, paper, binding, &c.; and as a specimen of superior American work, stands prominent, if not superior to any thing else exhibited as a book embracing every thing connected with it.

The Poets of America—a beautiful specimen of book making. This white calf binding is highly creditable to Mr. Moore, who is pre-eminent in such work.

Report on Chemicals.

The Committee on Chemicals report, that the articles submitted to their inspection evince a general excellence, which is in the highest degree creditable to the gentlemen concerned in their manufacture.

No. 18. Messrs. Harrison & Brothers exhibit an excellent lot, the greater part of which belongs to the committee on colors. The acetate of lead, from these gentlemen, is of exceeding purity and beauty.

No. 279, an excellent lot of preparations from Campbell Moffat, not inferior in beauty to those exhibited by the same young gentleman at the last exhibition.

No. 297. Messrs. Carter & Scattergood exhibit principally colors, which properly fall under the attention of another committee; yet this committee cannot pass, without approving notice, the excellent article of Prussian blue, which is superior to anything which they have heretofore seen of American manufacture, and which they therefore recommend to the Committee on Premiums, for a certificate of honorable mention.

No. 407. Farr, Powers & Weightman exhibit a number of chemical preparations, all of exceeding beauty and excellence. The high

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reputation of these gentlemen must be even increased by the skill and care exhibited in their preparations.

No. 464. Wetherill & Brothers have added much to the beauty and interest of the exhibition, by their display of crystals of sulphate of iron, nitre, and oxalate of ammonia, and especially by their specimen of corrosive sublimate shown, as obtained upon the lid of the crystalizing apparatus. The other preparations of these gentlemen are, as usual, excellent.

No. 323. Mr. Muzzey, agent of the New England Glass Company, exhibits a lot of glass for chemical purposes, which well merits attention from the convenience of form and excellence of manufacture. Its best qualities can only be tested by long use, but your committee strongly recommend it to all who require glassware likely to withstand the action of high and sudden heats, as well as of acids.

No. 168, a beautiful specimen of pure bone glue, from Mr. Gschwend.

No. 296, American salt, an article excellently fitted for table use, and equal to any imported.

Nos. 56 and 463, specimens of candles manufactured from lard, together with the oil obtained in the process, from Mr. Zeitler, and Messrs. Willis, Martin & Co. Both these articles are highly creditable to the manufacturers, and assume a higher interest from the importance of this branch of industry.

Nos. 242, 343, and 490, lots of perfumery, soaps, &c., from three different manufacturers—Mr. Roussel, Mr. Glenn, and Mr. Dingle. Your committee do not feel competent to develope the various merits of these articles; but if any judgment may be formed from the approbation of the ladies who visited the exhibition, their merits fully sustain the reputation of their manufacturers. The preparations of Mr. Roussel, in particular, evince a knowledge of chemical phenomena, and a nicety of manipulation, due to a strict education in the laboratory.

Upon a farther consideration, the Committee on Chemicals beg leave respectfully to recommend the following certificates of honorable mention:

No. 297, Carter & Scattergood, for their exceedingly beautiful specimen of Prussian blue.

Nos. 406 and 407, Farr, Powers & Weightman, for the general excellence and neatness of their preparations.

No. 242, Eugene Roussel, for his display of soaps, perfumery, cosmetics, &c.; the articles exhibiting a very decided superiority over any others which your committee has seen manufactured in this country.

Report on Philosophical Apparatus.

The Committee on the Philosophical Instruments at the exhibition, present the following report upon them, in the order in which they were enumerated in the catalogue.

No. 7, east and west compass. This instrument, the invention of

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M. S. Bassett, differs from the ordinary compass, in the substitution of a horse-shoe magnet for the straight needle. In both cases, the line joining the poles of the magnet is in the magnetic meridian, so that, notwithstanding its name, the new instrument is as much a north and south compass as the old one. It is susceptible, however, of being so employed as to exhibit the effects of local attraction, and on this account it formerly received a favorable notice from the Institute, and the award of a Scott's legacy premium. For the purposes of an ordinary compass, the committee do not think it possesses the advantages imagined by the inventor.

No. 13, electrotype medals, executed by Messrs. E. Parrish and R. Justice. There are five frames of these medals, presenting interesting specimens of this new and curious art.

No. 78, ear trumpet, by Dr. Young. This instrument is placed on a table, and the pavilion of the trumpet is turned toward the speaker, while the end of a flexible tube, attached to the other extremity of the trumpet, is held to the ear of the hearer. It is a European invention, and has been advantageously used, in this country, for some years.

No. 97, pulse-glasses, very well executed, by Mr. Heidrich. The pulse-glass is a well known instrument, used to show that, in a vessel freed from air, spirit of wine will boil at the temperature of the hand.

No. 98, frame of slides for the magic lantern. These slides appear to the committee to be as well executed as any that they have seen imported from Europe.

No. 129, Atwood machine, made by Dr. Wilson H. Pile. This instrument, so important for illustrating the laws of motion, is very well constructed, but has nothing novel about it, except an arrangement for marking the time elapsed during the motion, by striking the seconds on a bell.

No. 209, gold watch; movement (except the chain) made by Saml. Bland—case by Wm. Warner & Co.—dial by S. Mullen. It is a lever watch, and is, in all respects, a most creditable piece of workmanship.

No. 210, case of watch dials, by Wm. J. Mullen, executed with his usual well known skill and taste.

No. 228, spirit lamp, made by J. Bishop, on the plan of Berzelius, and well executed.

No. 224, theodolite, made by Edmund Draper. This useful instrument presents a specimen of excellent work, and is of the most approved construction. The verniers are supported on a hinge, so as to rest on the graduated limb with little force, and to move over it with little friction, and thus to prevent the abrasion which is often observed.

No. 256, philosophical apparatus, made by James P. Duffey. The instruments are principally electro-magnetic, and are exceedingly well executed. The committee think them worthy of an honorable mention.

No. 275, philosophical apparatus, by James Duffey, Jr. Some of these instruments are of the same class as the above; but among them the committee observed, with satisfaction, an ingenious and instruc-

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tive combination of the elementary machines, which they think may justly claim an honorable mention.

No. 356, clock of a new construction, by A. D. Crane. The regulating power of this curious clock is neither a pendulum, nor a balance; but a globe of brass is hung to the end of a long flat steel wire, which, being twisted round in one direction, is untwisted by the weight of the globe and its own elasticity, and wound round in the opposite direction, and so on alternately. At each of these movements, an appendage at the upper end of the wire acts upon an escapement of a peculiar construction, so arranged as to be nearly frictionless, but of which it would be difficult to give an intelligible description in this report. Although this revolving pendulum is no longer than that of an ordinary mantel clock, each revolution of the globe occupies half a minute; so that the movement of the clock may be maintained for a much longer time than in those in which the escapement is acted upon every second or half second. Accordingly, the clock sent to the exhibition is said to be capable of going an entire year, without requiring to be wound up. The committee look upon this as a new and interesting instrument, and recommend it as worthy of the award of a silver medal.

No. 400, type metal castings, by J. Creswell. These are castings from medals, made in sand, and are so sharp and smooth as to rival copies made by the electrotype process.

No. 517, occultator, by Thomas Hill. This ingenious instrument is constructed for the purpose of determining, without calculation, and by a rapid process, the circumstances of the occultation of stars by the moon, with sufficient accuracy to serve as a guide to the astronomical observer. It has already received a favorable report from a committee of the Institute, and it is certainly worthy of an honorable mention.

No. 519, electro-magnetic apparatus, by James Bingham. These instruments compare most favorably with those of the same kind already mentioned, and are equally worthy of an honorable mention.

No. 857, spectacles, by H. M. Pain & Co., Leicester, Mass. The glasses, which are ground by the manufacturers, are of the kind recommended by Dr. Wollaston, and which he called *periscopic*—that is, they are of the concavo-convex, or meniscus form, according as they are intended for near-sighted or far-sighted persons. The manufacturers claim that the lenses are truly parabolic. They appear to be perfectly well made, and the committee think them worthy of an honorable mention.

No. 872, transit or meridian circle, made by Wm. J. Young. This remarkable instrument is a most successful example of the highest class of mechanical skill. It is an exact copy of a meridian circle made by Ertel & Sons, at Munich, and now at the High School Observatory in Philadelphia. A description of it cannot be introduced into this report; but the committee have pleasure in expressing their belief that it is the most perfect, as well as the most difficult, work of he kind ever executed in this country, and, as such, they recommend that it have the award of a silver medal.

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The committee conclude their report by stating that many other excellent articles of philosophical apparatus attracted their attention, but that they were brought to the exhibition at so late a period as to be excluded by the rules from becoming the subjects of a report.

Practical & Theoretical Mechanics & Chemistry.

A Plan for the more speedy and effectual Extinction of Fires, especially in Dock-yards, and other Public Establishments. By D. J. MURPHY, *Holborn.**

The security of Her Majesty's dock-yards, on which so intimately depends the efficiency of our national bulwark—the British navy—is an object of such deep and vital interest, that any plan which may tend to effect so important a purpose, must be received with approbation, both by the government and the country. The principal, if not the only, means by which that security can be endangered, arises from the calamity of a fire occurring in any of our great naval arsenals, which may originate, either from accident, including spontaneous combustion, or from design. Due caution and vigilance will, in a great measure, if not entirely, prevent the latter cause; but the former source of such an evil cannot always be guarded against, as was fully evinced by the late fire which occurred in the dock-yard at Devonport, and the still more recent one in the armory of the Tower.

As it is, therefore, evident that the calamity of fire cannot always be prevented from occurring by the greatest care and caution, the next best mode of security is, to be enabled to diminish its injurious effects in the shortest time possible, by checking its ravages in the most effectual manner. The most general, in fact, almost the only, agent employed to accomplish this purpose, is water, discharged from fire engines. Now, water is, in a great proportion, composed of oxygen, the chief nourisher of flame, and, therefore, it has seldom the desired effect, except it be discharged in sufficient quantities, so as to act by its weight and volume, and thus to stifle, or smother, as it were, the flame. Thrown in small quantities, which must always be the case when discharged from fire engines, and when the flame has reached a considerable height, the water only supplies fuel to the flame,† or else is rarefied into steam from the great heat that arises. Even when discharged in sufficient quantities, so as to reach the source of the flame, its effects are only temporary, and it does not

* Communicated by J. Tyler, Jr., Esq.

† This view, that water is decomposed when thrown upon a fire, we conceive to be erroneous, but retain the author's words.—Com. Pub.

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prevent the burning material from catching the flame again, when the extreme heat has dissipated, or dried up the moisture. Without the necessity of adducing as an instance the late great fire at Hamburgh, all experience confirms the fact that pure water is either an inefficient, or only an inadequate agent for subduing the ravages of an extensive fire, within a certain limited period.

Next, if we look to the origin and course of fires in general, we find that at first they make little progress in most substances. Wood, or timber, except in some peculiar circumstances, is the chief article on which they operate, and even with this, unless accompanied by flame, their advance is slow. It is the blaze, or flame, which arises, that always extends the fire, and commits the greatest ravages; and if the former can be speedily extinguished, the latter will expire of course. Yet the means for effecting this very important object are simple and efficacious, and it only surprises how long they escaped the researches of scientific men. The story of Columbus and the egg may well apply in this case, as being another apt illustration how easily the cause is overlooked, and simple means are neglected in seeking for a remedy. Hence the multitude of plans for fire-escapes, and other modes of diminishing the dangers and lessening the calamities arising from the frequency of fires.

The process now proposed for extinguishing fires speedily, is simple and effectual, and does not much interfere with the machinery employed at present. It is merely saturating the water discharged from the fire engines with a certain proportion of the chloride of sodium, or muriate of soda, (common salt,) and potash, both cheap articles; and indeed the former alone will be found quite effectual in all ordinary cases. The proportion of these ingredients to be employed may vary from one-tenth to one-thirtieth of the weight of water so discharged, of which it will be found that a considerably less quantity will be required from being so saturated. In low elevations, and when the flame has not reached a great height, the stronger impregnation may be used with advantage; but where the flame has arrived at a considerable elevation, the weaker impregnation can only be employed, arising from the greater resistance of the air, the increased weight of the materials, and the augmented difficulty of passing through the valves of the fire engine; though, even then, the stronger impregnation can be successfully discharged to attack the flame at its base, or root, which is perhaps the best course to pursue in all cases. A fireman in his ordinary dress, and only simply armed with an elastic tube conveying this stronger impregnation, may boldly and securely face the strongest and fiercest flame, and make himself a passage through it, by commencing, cautiously at first, to discharge

the impregnation on each side of him, for, where it falls, it not only subdues the flame, but, by leaving a coating of the materials, it prevents the flame from readily catching again the substance on which it previously fed; the result being, that the muriatic acid of the salt becomes volatilized and flies off,* while the soda, which is indestructible, is converted into a glaze on the surface. The root, or base, of the flame, is, therefore, the point to which the force, power, and efficacy of the impregnation, ought always to be directed.

This impregnation, it is to be observed, can be so managed, by the addition of other ingredients, when found necessary, or where the expense is disregarded, such as the diluted mineral acids and their salts, as to produce a temperature approaching, and even considerably below, the freezing point on Fahrenheit's scale, and yet preserve its fluidity; for it is by its chemical combination it acts against the flame, and also in serving to reduce the temperature of the surrounding heated atmosphere. The effect of several engines acting at the same time by the weaker and stronger impregnations, must be all-powerful, as may be easily conceived; and no fire, whatever degree of head it may have previously attained, can resist the power and efficacy of this impregnation for any period exceeding half an hour, though the fire at the Devonport dock-yard continued to rage for more than six hours. Even water saturated with fine clay, slacked lime, finely powdered chalk, &c. &c., all cheap articles, and slow conductors of heat, may be employed with great advantage on flames of low elevation; for it is desired to impress the idea that water alone is used as the medium for conveying these substances, as well as the others, to the body of the flame, or rather to its source, such as the body on which it feeds. Let this be completely coated with those ingredients, for the water will be quickly evaporated by the intense heat; and the effect produced, namely, the extinction of the fire, will be the immediate and necessary consequence.

The security which this plan affords for the protection of Her Majesty's dock-yards from the extension of a fire occurring there, is certain and infallible; because, in this case, the stronger impregnation can be employed without any difficulty, together with such additional ingredients as must make it all-powerful, and because the necessity of using fire engines can, in a great measure, if not entirely, be dispensed with. To accomplish this object, it will be necessary to construct an elevated and covered tank, in any central and convenient part of the dock-yard, which tank may be about 60 feet long, 30 wide, and 5 deep, which will contain about 250 tons of the impregnated water, or

* Common salt is not decomposed by heat, as is here supposed, but actually *volatilizes* without decomposition.—Com. Pub.

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about 9000 cubical feet; and, as each cubical foot weighs 62 lbs.,* it will contain 558,000 lbs., or about 55,800 imperial gallons, each gallon weighing 10 lbs. This quantity is fully more than sufficient to extinguish any fire, even if it raged to the extent of the late one at the Devonport dock-yard, because the effect of the impregnated water is more powerful and more instantaneous, in a considerable degree, than water in its pure state. The elevation at which the tank should be constructed may be thirty feet, or about two-thirds of the height to which a first rate ship of war on the stocks may reach. Now, for the purpose of conveying the impregnation directly to the body of the fire, it will be necessary to provide elastic tubes of a greater diameter than those at present attached to fire engines, and to have them previously prepared to screw on a certain number of stop-cocks at all sides of the tank, near its bottom, by which the impregnation can be brought to bear at once on the fire, and, of course, will command and extinguish all within the range of, and below, this elevation; and the force and weight of the body of the impregnated water, at its source in the tank, will raise it to a higher elevation if the fire originate above this level, or a very small force only will be necessary to be employed to give the due elevation above the level of the bottom of the tank. To preserve the impregnation in all its parts, and at all times, duly saturated, it will be necessary to have three or more small vanes, with short sails attached, like the arms of a windmill, to be operated upon by the wind, and projecting from the top of the tank, so as to give motion to a certain number of horizontal paddles, extending to near its bottom, by which the impregnated water will be preserved constantly in a due state of preparation for use. The same course as here detailed may be pursued for the extinction of fires in, and preservation of, all the other public establishments.

With fires originating in private houses, manufactories, &c., the means of preparation and security cannot be so easily provided or adopted, and, of course, their more speedy and effectual extinction must arise from the efficacy of the impregnated water when discharged from fire engines; and, in this case, it will be necessary to provide, and to have each engine accompanied by, a tender on wheels, and the larger the better, in which the prepared ingredients can be kept in a due state of agitation by any motive power, or such as the engine itself is worked with, and through which the water must pass from the source of supply to the engine, by which means it will take with it a certain proportion of the ingredients so dissolved and diffused. The tender attached may be 8 feet long, 4 wide, and 4 high, and will

* This number is nearly the weight of a cubic foot of water without the salt, but the error is unimportant.—Com. Pub.

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contain 128 cubical feet of the impregnated water, or 3½ tons, or about 800 gallons,—a quantity almost certain of extinguishing the ordinary range of fires; for it is scarcely necessary to observe that a smaller quantity of water will be required when so impregnated, than in the usual course pursued at present. A very few tons will then be sufficient to extinguish, in a short time, the most intense and extensive fires; whereas, according to the present mode of proceeding, several tons are necessary, and a long period of time, to produce the desired effect.

If the increased expense of the new plan be estimated, it will be found insignificant, compared with the benefit it will confer, and the innumerable evils and calamities which will be prevented. Taking the average of the quantity of the ingredients required, as forming one to twenty of the weight of water, it would amount to about 400 lbs. of salt and potash to saturate sufficiently the above quantity, and the estimated cost of these ingredients would not much exceed thirty shillings,—an expense no insurance company would withhold, with the certainty of saving some thousands of pounds' worth of property, and probably the lives of a few human beings. But even this is the very highest estimate of the expense; for, from some small experiments made by the proposer of the plan, he has found that, with only 4.10 parts of common salt to 95.90 of water, which reduced the temperature to 27.9* degrees on Fahrenheit's scale, fully three degrees below the freezing point, this slight impregnation was discovered to be sufficiently effectual, and produced a surprising effect. The proportion, however, is always to be regulated, not so much by the height of the flame, as by the height of its source, or the materials on which it feeds. This, in general, is not higher than the first, second, or third floor of a dwelling house; and the proportion of ingredients may be regulated accordingly, which a small degree of practice will soon ascertain, and so as to admit of good working order in the engine; but, taking the quantity as above, about 100 pounds' weight of salt will be thus conveyed and spread over each floor of the house. And here it may be necessary to observe, that the pumps employed in drawing up the brine from the salt pits in Cheshire, for the purpose of converting it into manufactured salt, are used on much stronger impregnations than any that will be required, by this new plan, to pass through the fire engines.

The same principle, which, it is evident, solely depends on the efficacy of the impregnation, may be carried into effect in subduing and dissipating the foul and inflammable air which is sometimes generated

* The temperature to which the salt reduces the temperature of the mixture depends essentially upon the previous temperature, which is not here stated.—Con. Pub.

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in coal, and other, mines, and which so frequently leads to the destruction of many lives. Any necessary degree of strength can be given, in this case, to the impregnation, and it will have the same beneficial result by purifying and neutralizing the baneful effects of this inflammable gas; for which purpose it will be requisite only to employ a small engine, or even the small garden machine for spreading water over flowers and vegetables. One of these may likewise be preserved in dwelling houses, and used with advantage in many cases, when charged with the impregnated water, in checking and subduing the incipient origin of many fires.

Having thus detailed the principles, and the full practical workings, of the plan for extinguishing fires more speedily and effectually than heretofore, it only remains for a humane and intelligent government to carry it out into full operation, as far as the protection of the national establishment is concerned. As for the proposer himself, he will always feel bound to bow with grateful thankfulness to the Great Disposer of events, for being made the humble instrument in conveying so important a discovery; and it will ever afford him a subject of consolation, under all circumstances, that he will have contributed to lessen some of the calamities and sufferings which so frequently arise from sudden and unexpected fires.

The Practice of Fresco Painting.

Extracts from Appendix to Report of Commissioners on Fine Arts, for decorating the new House of Commons.

The whole scheme and invention of a series of frescos should not only be settled, but all the large drawings made, by the time the building is ready; for the work can then advance rapidly. Supposing the present buildings to be ready in seven years from this time, Cornelius says it is time to begin the designs. The German artists, expert as they are in drawing, always take some years to prepare their cartoons. Cornelius' cartoon for the altar-wall of the Ludwig-Kirche at Munich, was executed in Rome; he went there for the purpose. If Westminster Hall, or any other building already in existence, is to be adorned with frescos, the wall should be prepared with the first rough coat of mortar at once; for this ought to be on the wall, if possible, for some years before it receives the final preparation immediately before painting, unless very old lime be used in the first instance: but, even in that case, six or twelve months should elapse before painting on it, to give it ample time to harden.

The Cartoon.—It may be assumed that it is impossible to retouch a fresco painting to any extent. The portion of the work undertaken in the morning must be completed during the day. The partial remedies and contrivances in case of unavoidable delay, or accidental defects, will be hereafter considered.

Hence every part of the design must be defined in preparatory

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studies; the fresco is, in fact, a copy from these, the forms being *traced* on the wall from drawings the full size. [Cartoons of the kind prepared for fresco (that is, without colors) may be seen in the National Gallery; namely, those at the head of the staircase, by Agostino Caracci.*] When the painting is to be very large, and it is found inconvenient to prepare a cartoon of the same size, the drawing may be made half the size; or, the whole composition of the full size may be divided into two, or more, cartoons; [thus Raphael's cartoon for the school of Athens, preserved in the Ambrosian Library at Milan, contains the figures only, without the architecture.] It is scarcely necessary to observe that the cartoon itself is, in the first instance, generally enlarged from small drawings of the whole composition, with the aid of careful studies for the separate parts. The following is the mode in which Cornelius prepares and fixes his cartoons. A strong cloth is stretched on a frame, as if to be prepared for painting; paper is then firmly glued on the cloth. When this first layer of paper is quite dry, a second layer is carefully glued over it in the same manner. The edges of the separate sheets are a little scraped, where they overlap, in order to preserve an even surface. The surface is then prepared for drawing, with size and alum. The drawing is made with charcoal, and, when finished, is *fixed* by wetting the back (the cloth) with cold water, and then *steaming* the drawing in front. The effect of this last operation is to melt the size a little, thus fixing the charcoal.

A finished drawing of the full size being thus ready, the outline is *traced* from it on oiled (transparent) paper; if the finished drawing is half the size, it is enlarged by squares to the full dimensions, portion by portion: in this case, the paper on which it is copied should be moderately thin, for the convenience of tracing on the wall. A part of this "working" outline (as much as can be finished in one painting) is now nailed to the wet wall, and the forms are again traced with a sharp point, which makes an indented outline through the paper on the soft plaster. The "working" drawing is generally destroyed in this operation. [The following is another mode: the paper to be applied to the wall is placed behind, and in close contact with, the finished cartoon; the outlines of the latter are then pricked, and the operation necessarily leaves a similarly pricked outline on the paper behind. The next process is to pounce the pricked outline of the latter, when fastened to the wall, with a little bag of black or red dust: this leaves a dotted outline on the wall. This method is sometimes adopted for small works, as the surface of the plaster thus remains undisturbed.] The first mode—tracing on oiled paper, and then again from it to the wall—is, however, generally preferred, since it insures the best and most decided outline, while the finished cartoon may be preserved uninjured. In many celebrated Italian frescos, the indented outline, produced by tracing, is apparent.†

* Agostino Caracci assisted in the frescos of the Farnese Palace, and the two subjects in question were, it appears, designed and executed entirely by him. See Lanzi, v. 5, p. 74, and Malvasia, v. 1, p. 439.

† The outlines of Raphael's cartoons are covered with pin-holes. This is very apparent, also, in the fragment of the cartoon for the Murder of the Innocents, now in the National

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It has been already observed that the fresco is a final operation; any considerable alterations that may suggest themselves when the cartoon is completed must be made on the cartoon, or, rather, on additional pieces of paper fitted upon it.

[One of the most interesting examples of the nature and extent of the alterations that may be introduced in a composition prepared for fresco, is the cartoon, already referred to, of Raphael's School of Athens. The changes are mostly additions. The figure of Epictetus, represented, in the fresco, sitting in the foreground on the left, leaning his head on his hand, is wanting in the cartoon. This figure was added to fill up a vacant space, and thus the change, though a considerable improvement, involved no inconvenience. Some less important alterations in the same fresco, such as covering the head of Aspasia with drapery, instead of showing her flowing tresses, (for thus she appears in the cartoon,) might have been made on the wall, without any change in the drawing. That this cartoon was the identical one which served for the execution of the fresco, is proved by the exact conformity of every part, except the additions above mentioned, with the painting.]

Beside the cartoon, in which the forms and general light and shade are determined, it is desirable to have a colored sketch of the whole composition, for it is almost as impossible to change colors, as forms, after the fresco is done. In general, the German painters are not in the habit of making complete colored sketches for this purpose.

The Preparation of the Wall.—If the wall to be painted is covered with old mortar, the ingredients of which are unknown, this coat should be entirely removed till the solid materials are laid bare. The rough coat then applied is composed of river sand and lime. The proportions of the sand to the lime may vary in different climates, and the working builder and mason are sufficiently experienced on this point. In Italy, it appears that two parts of sand were added to one of lime; the Germans generally use more sand, viz., three parts to one of lime. The thickness of the coat is such as is generally used in preparing the walls of dwelling houses. The surface of this first application should be rough, but not unequally so; and the mason should avoid leaving cavities in it.

The wall, thus prepared, should be suffered to harden perfectly; the longer it remains in this state, the safer it will be, especially if the lime used was, in the first instance, fresh. In that case, two or three years even should elapse before any subsequent operations are undertaken. Among the essential conditions of fresco painting must be mentioned the preparation and seasoning of the lime. At Munich, it is made and kept as follows:—A pit is filled with clean, burnt limestones, which, on being slaked, are stirred continually till the substance is reduced to an impalpable consistence.* The surface having settled to a level, clean river sand is spread over it to the depth of a foot, or more, so as to exclude the air, and,

Gallery. Of the cartoons above mentioned, by Agostino Caracchi, one (the Triumph of Galatea) has the pricked outline; the other (the Cephalus and Aurora) not.

* The Italian mode is somewhat different.

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lastly, the whole is covered with earth. The German painters suffer the lime to remain thus for at least three years before it is used, either for the purposes of painting, (for lime is the white pigment,) or for coating the walls. Cornelius prepared the lime for the Ludwig-Kirche eight years before he painted there. A great quantity is generally kept in Munich, and might, perhaps, be had from thence for works in this country. The late Lord Monson intended to have had lime from Munich for the works which Cornelius was to have done for him at Gatton. The pits, or vats, in which the lime is preserved, are not lined with brick, nor protected in any way; they are dug in the mere earth. The lime thus kept is found moist, as at first, after many years. Cornelius said that there might perhaps be no objection to lining the pits, so as to keep the lime clean, but that the usual mode was to slake it and keep it in the mode described.*

The ultimate preparation for painting on the dry, hard, well-seasoned mortar is as follows:—The surface is wetted again and again, with water that has been boiled, or with rain water, till it ceases to absorb. Then a thin coat of plaster is spread over that portion only which is to be painted; the surface of this coat should be but very moderately rough. As soon as it begins to *set*, (in ten minutes or so, according to the season,) a second thin coat is laid on somewhat fatter, that is, with more lime and less sand—about equal proportions. Both these layers together are scarcely a quarter of an inch thick. The plaster is laid on, and the surfaces are smoothed, with a wooden trowel—this, at least, is Cornelius' practice. Some painters like the last surface (which is to receive the fresco) to be perfectly smooth; one of the modes of rendering it slightly rough is, to fasten some beaver nap to the trowel; another is, to pass over the plaster, in all directions, lightly, with a dry brush.

The Process of Painting.—A portion of the outline is now traced with a sharp point on the plaster, as before described, and the painter begins to work when the surface is in such a state that it will barely receive the impression of the finger, and not so wet as to be in danger of being stirred up by the brush; besides other inconveniences, this would fill the brush with sand. If the wall has been previously well wetted, the plaster will not dry too rapidly; but if, during the course of a dry summer's day, the surface begins to harden too much, and no longer takes the color well, the painter takes a mouthful of water from time to time, and sprinkles it over the surface, in the same manner as sculptors sometimes wet their clay models. Much evidently depends on the thorough wetting of the dry mortar, before the last preparatory coats are applied.

In painting, it will be found that the tints first applied sink in and look faint, and it is necessary to go over the surface repeatedly before the full effect appears. But, after some time, especially if the surface be not occasionally moistened, the superadded color will not unite with what is underneath. The change, in some of the colors, from the wet to the dry state, can be best learned by experience; but it is usual to try the tints, at first, on a brick, or tile, that absorbs moisture.

* Professor Hess directs the lime to be kept in pits lined with brick.

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After having completed the portion allotted to the day, any plaster which extends beyond the finished part is to be removed; and in cutting it away, care must be taken never to make a division in the middle of a mass of flesh, or of an unbroken light, but always where drapery, or some object, or its outline, forms the boundary; for, if this be not attended to, it is almost impossible, in continuing the work the next day, to match the tints so that the junction shall be imperceptible; but by making these junctions correspond with the outlines of the composition, the patchwork which is unavoidable is successfully concealed.

In the next day's operation, the surface of the old mortar is to be wetted as before, and care must be taken to wet the angles round the edge of the portion previously painted. This requires to be done delicately with a brush, in order to secure the sufficient moistening of every minutest corner, and also to avoid wetting or soiling the surface of the finished portion. On this last account, it is better to begin from the upper part of the wall; for, if the lower part is first finished, the water constantly runs over the fresh painting.

When the painter is unable to finish a portion at once, or is compelled to leave it during the day for a considerable time, the Munich artists have a contrivance which arrests the drying of the work. A board is padded on one side, the cushion being covered with waxed cloth; a wet piece of fine linen is then spread over the fresh plaster and painting, and pressed to the surface of the wall by the cushioned side of the board, while the other side is buttressed firmly by a pole from the ground.

When any defect in the first operation is irretrievable, the spoiled portion is carefully cut out, and the process above described is renewed for that particular part. The same remedy is possible in reviewing the finished work; but here again care should be taken that the portion cut out should be bounded by definite lines, for the reason before given. This attention to the nice adjustment of the successive portions of the work, so as to make one whole in the mere execution, is of great importance in fresco painting.

In the finished fresco the depth of shadows is often increased, parts are rounded, subdued, and softened, by hatching in lines of the color required, with a brush not too wet, the medium then used being vinegar and white of egg. Shade is more easily added in this way than light; but some use crayons, made of pounded egg-shells, to heighten the lights. It is to be observed, that such re-touchings are useless in frescos painted in the open air, because the rain washes them away, whilst the rain does not affect frescos painted without re-touchings; of this, the paintings on the Isar-Thor, at Munich, are a sufficient proof. [Cavaliere Agricola, who, as before observed, has lately published a report on the Roman frescos, is of opinion that they were re-touched with colored crayons. Vasari,* however, distinctly says that frescos which were not re-touched, were least subject to alteration and decay.] Various methods of this kind have, nevertheless, been resorted to by the Munich painters, and Cornelius has mentioned some.

* Introduzione, c. 19, and Vita di Antonio Veneziano.

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The Colors and Implements.—These details, communicated with all-sufficient precision by Cornelius, need not be inserted here, as they are given in other papers that follow. The colors are chiefly simple earths; no vegetable, and few mineral, preparations can be used with safety, but there is a mode of rendering vermilion durable. The palette is of tin, with a rim round it to prevent the colors, which are thinned with water, from running off. The colors, mixed or ground in water, are kept at hand in small pots. The brushes are of the usual materials, but they should be somewhat longer in the hair than those used for oil painting.

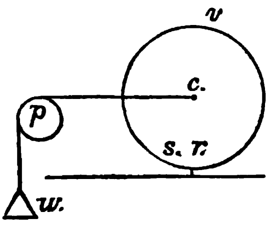
(To be continued.)

On a supposed Error in the "received Theory" of Rolling Bodies. *By* THOMAS W. BAKEWELL.

Let two cylinders, similar in all respects, except that one has a given weight placed around the axis, and the other an equal weight distributed near the circumference.

It is orthodox that the cylinder with the weight at the circumference will require a greater force to attain a given velocity, in a given time, on a horizontal plane, and require a longer time to descend a given inclined plane, than the other, in consequence of the retarding effect of the weight at the circumference, to its gaining a rotation on its own axis. And I have noticed this supposed retarding force in the wheels of a railroad train, to form an item in calculating with exactness the required force to give motion to the train.

I believe these views to be erroneous, and offer the following reasons for my opinion:



In the figure, let *c* be a cylinder, with the weight at the circumference, on the horizontal plane, and impelled by the weight *w*, leading over the pulley *p*. And let points project from the cylinder, on which it should rest successively, as *s*, *r*. Now, when the point *r* is on the plane, and in the *interval of time* required for the cylinder to roll, before the point *s* should rest on the plane, the required velocity of the weight at *v* would be a retarding force; but when the point *s* should touch the plane, the velocity of *v* becomes an acceleration of equal value.

In this view of the case, the cylinder with the weight at the circumference would still require a greater force, or longer time, to attain a given velocity, than the other, by reason of the acceleration being "one step" in arrear of the retardation.

But if we reduce the coarseness of my illustration to the minuteness of reality, the resting points of the cylinder would be, to each other, infinitely near—or, in other words, would present a smooth surface, when there would be no *interval of time* between the retardation and acceleration, for the two forces would be co-existent.

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If the horizontal plane were prolonged, and the impelling force removed, would the cylinder, being in motion, roll to a greater distance by having the weight at the circumference? The orthodox answer is in the affirmative, from which I am compelled to dissent; for when the weight *w* is accelerative by its velocity at *v*, the equal weight at *r* is motionless on the plane, and the acceleration of weight, *v*, is neutralized in bringing the weight, *r*, from a state of rest up to its own velocity.

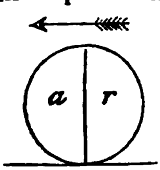
This point may be rendered more obvious by using the inclined plane, or planes, in the form of the arc of a circle, on which the cylinders should roll, or vibrate; when, by a series of vibrations, the difference of time (if any) would be readily detected.

On the threshold of the supposed trial on the arc of a circle, we have, on the received theory, this difficulty:

What becomes of the retarding force of the weight at the circumference to its rotation on the descent, when arrived at the bottom of the arc? The weight at the circumference is now accelerative, and a greater distance on the ascent becomes inevitable.

The extraordinary result is thus forced upon us, of a weight raising itself to a point higher than its original position, by the instrumentality of a retarding force.

The following statement of the principle for which I contend, made in as plain a manner as I am able, must, I think, be self-evident:



Let any cylinder be in motion (rolling) on a horizontal plane, in the direction of the arrow, as by figure 2; bisect the cylinder, perpendicular to the plane. Then no part of the half, *a*, can move in its rotation on the axis, without decreasing its velocity in the direction of the arrow, and parallel with the plane; and in acquiring this decrease of velocity in the direction of the arrow, it draws forward the cylinder, and is *acceleration.*

No part of the half, *r*, can move in its rotation on the axis, without increasing its velocity in the direction of the arrow, and parallel with the plane; and, in acquiring this increase of velocity, it draws backward the cylinder, and is *retardation.*

These forces are always equal, under all velocities, and on all planes, inclined or horizontal.

Cincinnati, Nov. 16, 1842.

On a prevailing Error in estimating the Strength of Cylindrical Boilers. By Thomas W. Bakewell.

The Journal of the Franklin Institute for Nov. last contains a report relative to the facts and probable causes of the explosion of a boiler in the steamboat Medora, at Baltimore. This report affords another instance of respectable authority to a prevailing and dangerous error in estimating the capabilities of cylindrical boilers to sustain a given pressure of steam. It is there assumed that the force exerted to burst a cylindrical boiler, say at the top and bottom, as at *c* and *d* in the figure, is as the pressure on a space equal to the diam-

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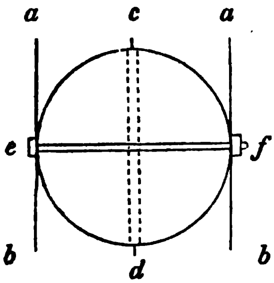
eter, or as the base *a b*, and of equal dimensions, lengthwise of the boiler, to any portion of the boiler assigned for investigation—for instance, a ring of one inch in width, and forming part of the boiler.

The error seems to exist by considering each half of the boiler, which the steam tends to separate at *c* and *d*, as a strong and stiff body, capable in itself of sustaining its shape; and that the *horizontal* action, alone, of the steam, in the example now given, to sunder the parts at *c* and *d*, requires to be examined.

In practice, all cylindrical boilers may be considered as composed of a flexible material, and especially when of the size of that in the Medora—132 inches in diameter; and their strength to consist in the tenacity of the boiler iron to resist a direct pull, the resistance to the steam by stiffness being scarcely appreciable.

Let the figure represent a ring, one inch in width, and forming part of a boiler; let it be cut at *c* and *d*, and the edges held together by the horizontal bolt, *e*, *f*—thus forming, by supposition, a steam-tight joint. Now, we can readily conceive how slight a pressure upwards and downwards would open the joint at *c* and *d*, notwithstanding the *horizontal* bolt, *e*, *f*, being in a position to sustain any pressure, thrown into a horizontal action, as contemplated by the received rule. But, if we first brace the boiler by the vertical bolts, where marked by the dotted lines on each side the joint, (waiving the action of the steam on the spaces between the letters) we should convert each half into a stiff and strong body, capable of retaining its shape; and then the received rule would be correctly applicable, viz., that the force to separate the boiler at *c* and *d*, would be as the pressure on a space, equal to the diameter, or as the base, *a*, *b*; and the horizontal bolt sustaining that pressure, would prevent the boiler parting at *c* and *d*.



Let us now suppose the boiler entire, (not cut,) and the vertical bolts removed; then, if steam be admitted, the boiler must sustain, by horizontal tension, at *c* and *d*, in the disadvantageous manner of a string, stretched horizontally, bearing weight, what was previously sustained by the vertical bolt; and this mode of action by the steam is neglected by the received rule.

In the above exemplifications, I have granted an item beyond what exists in reality. It is, the continuance of the horizontal bolt in position to prevent, effectually, on the received opinion, the separation at *c* and *d*—although, in treating the ring, or boiler, as it is, in fact, of a flexible material, no efficient support could be derived from the horizontal bolt by the parts *c* and *d*. And if we again introduce the vertical bolts as by the dotted lines, the parts *c* and *d* would be completely protected, and the pressure might be urged to bursting, when the boiler, or ring, would part in the middle of one of the spaces, between the letters.

On the received rule, the horizontal bolt is the ostensible support of the parts at *c* and *d*, and the vertical bolts negative in their effects;

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but if we remove the horizontal bolt, and let the vertical bolts remain, the parting point would be yet more determinately removed from the said parts, *c* and *d*, and would be at *e*, or *f*.

I have thus endeavored to show a deficiency unprovided for in the received rule, which, when included in the estimate, makes the effective force to tear asunder the boiler at *c* and *d*, equal to the sum of the pressures on the semi-circumference; which force is sustained, one-half each, by the parts at *c* and *d*, being as the pressure on the quarter circle to part the boiler at any one point—whereas the received rule gives the force as the pressure on half the diameter, and the difference is as 1.57 to 1.

In the Journal of the Franklin Institute, Vol. IV, for Aug. 1829, may be found a communication from me on this subject, wherein a mode of arriving at the value of my estimate is shown; and although there are other methods of demonstration, perhaps the one there offered may be as obvious as any. I apprehend, however, no confliction on this head, for the result flows from acknowledged laws.

The main object of the present article is to call attention to the very serious error in the premises on which the prevailing opinion is predicated, and to the important fact that there is 57 per cent. more force exerted by steam of a given density to cause an explosion, than is usually assigned.

With respect to the boiler of the Medora, the same discrepancy exists between the estimated pressure, by the received rule, of what it would bear, and the amount established by the witnesses—as in most cases of explosions—when far-fetched and improbable causes are enlisted to fill the gap between the engine builder and engine tender.

The conviction of the correctness of my views in this matter is not lessened by their being conceded by men, to whom they have been presented, whose attainments embrace the subject, and whose opinions are entitled to every consideration.

Cincinnati, Dec. 6, 1842.

Description of a Flax Mill recently erected by Messrs. Marshall & Co., at Leeds. Communicated to the Institute of Civil Engineers, by James Combe, Assoc. Inst. C. E.

The mill described in this communication consists of one room, 396 feet long by 216 feet wide, covering nearly two acres of ground. The roof is formed of brick groined arches, 21 feet high by 36 feet span, upon cast-iron pillars; an impermeable covering of coal-tar and lime is laid on a coating of rough plaster over the arches, and upon that is a layer of earth, 8 inches thick, sown with grass. This immense room is lighted and ventilated by a series of skylights, 13 feet 6 inches diameter; one at the centre of each arch. A vaulted cellar with brick pillars extends under the whole of the building, and contains the shafts for communicating the motion from a pair of engines of 100 horses' power, to the machinery in the mill; the flues and steam cases for warming and ventilating; the revolving fan for urging the air into

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the room, with the gas and water pipes, and the remainder of the space is appropriated for warehouses.

The heating and ventilating are effected by a large fan, which forces the air through the pipes of two steam chests, each 10 feet long, and containing together 364 pipes of 3¼ inches bore: the temperature can be regulated by the quantity of steam which is admitted into the chests, or by allowing a portion of cold air to pass by without traversing the pipes; valves and doors in the flues permit any temperature which is desired to be obtained, or that degree of moisture which is essential for some part of the process of working flax. The general details of the construction of the building are given, with the dimensions of the brick and stone work; the cast-iron pillars and caps, the wrought-iron tie-bars, with the reasons for adding a second set after the accident occurred to the first set; the mode of drainage from the roof, and the striking the centres of the arches, &c.

The total cost of the mill, including the ornamental stone front, was £27,443, which is stated to be about the same cost as that of a good fire-proof mill on the common plan; but as this mode of construction was novel to the workmen, it is probable that a second building of the kind would be less expensive. The advantages resulting from the plan are, convenience of supervision, facility of access to the machines, the power of sustaining uniformity of temperature and moisture, the absence of currents of air which are so objectionable in other mills, the simplicity of the driving gear, and the excellent ventilation which is so desirable for the health of the workmen.

The paper was illustrated by two drawings, with a sheet of reference; and an appendix contained the result of some experiments upon the strain on the tie-bolts, the pressure on the arches, and the deflexion of the bolts, &c.

Remarks.—Mr. Smith, of Deanston, was much pleased to find this description brought before the Institution, as he was the first to adopt it for a weaving shed of the extent of half an acre; the columns for carrying the arches were thirty feet six inches apart, and the skylights were eight feet in diameter; some of the arches were of brick, with stone springers; others were entirely built with rubble stone, well grouted, which latter mode of construction he found succeeded quite as well as brick: the settlement of the arches, on striking the centres, after standing four days, was only three-fourths of an inch. The arches were thickly plastered with common mortar, and, at first, were only covered with a coating of boiled coal-tar pitch, and lime three-eighths of an inch thick; but, as the wet penetrated, the thickness of coal-tar pitch was increased to three-fourths of an inch, with a mixture of sharp sand, which had proved perfectly water-tight: for some months there was an appearance of moisture, which proceeded from the interior of the brick-work, as it could not escape outwards on account of the impermeable covering; after some time, the copious ventilation carried off this moisture, and the building became perfectly dry. Over the coal-tar a thickness of earth is laid, which is cultivated, and has proved a prolific garden: in severe weather, the frost has not reached above one and a half inch deep in the soil, while it has

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penetrated to the extent of twelve inches in other situations. The construction of the floor is peculiar: it is desirable in such weaving sheds to have a boarded floor, to prevent the small parts of the machinery from being broken by falls, and also on account of the health of the persons employed; but the vibration of an ordinary wood floor is objectionable. In order to meet these views, a bed of concrete was laid throughout the building—a series of small deal spars, one and a half inch deep by one inch wide, were set flush into the concrete whilst it was wet, and the whole surface was smooth plastered: upon this bed, when it was perfectly dry, a floor of boards, one and a quarter inch thick, was nailed to the spars; it was found to combine the solidity of pavement with all the advantages of a wood floor, and there had not been any symptoms of dry rot—which might be attributed to there being no cavities left beneath the boards, the whole being firmly bedded down. The ventilation was effected by tunnels beneath the floor, the covers of which were pierced with a number of small holes to spread the air. The warming was accomplished by means of hot water circulating under the pressure of the atmosphere only, in "tubes of tin plate," four inches diameter; the temperature was very regular, and perfectly under control. With one ton of coal per week, the shed could be kept up to 70° during the winter. The cost of this building was 30 shillings per square yard of area covered, which was less than the cost of Messrs. Marshall's mill; but building materials were much cheaper at Deanston than at Leeds. He expected that this mode of building would become more general, as it combined many advantages, and, whatever might be the first outlay in purchasing ground, the cost of which was the only inducement for constructing buildings of several stories in height, it would be fully compensated by the facility of superintendence alone, as, in manufactories, this was of the utmost importance. These buildings would, he believed, be eventually used for agricultural purposes, and, when engineering knowledge was more directed to the processes of agriculture, good results might be anticipated. His attention had been particularly directed to the subject, and he was convinced of the necessity of concentrated superintendence, which is not at present possible in the separate farm-steadings as they are now constructed. This might be apparently foreign to the subject before the meeting; but the range of engineering was so wide, that it was difficult to say where it should stop.

Mr. Lindsay Carnegie, as a landed proprietor, could bear testimony to the importance of the connexion of engineering with agriculture, and to the advantages already derived from the improvements which had been introduced by Mr. Smith, who might be justly termed the father of the improved system of agriculture in Scotland.

Mr. Marshall explained that he was indebted to Mr. Smith for the suggestion of this mode of construction, which he had not hesitated to adopt, although all the plans had been prepared for mills of several stories in height—he had been convinced of the superiority of the present plan, and his expectations had been fully realized. There were, of course, some difficulties to be overcome, and some experiments to try,

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all of which had not been successful; but, in all the essential points, this kind of building was superior to any other. An equality of temperature, and a facility of imparting a certain degree of moisture to the air, which was indispensable for spinning yarn, had been perfectly attained.

Mr. Braithwaite inquired whether the arches were found to be perfectly water-tight? On some of the railways which were laid upon arches, it had been found that asphalte had failed in rendering them impervious, and they were, consequently, useless, even for storehouses.

Mr. Marshall explained that a few leaks had occurred, particularly near the skylight frames, but they had been easily repaired, and were now water-tight.

Mr. Combe found that a mixture of finely sifted engine ashes with the coal-tar pitch was better than lime. The depth of soil above the arches should be sufficient to prevent the heat of the sun from penetrating through the cracks to the pitch, and forcing it up. He had recently examined the roof carefully, and could only discover six indications of moisture penetrating; these had been easily repaired, and all was now perfectly sound.

Mr. Field agreed with Mr. Smith in his estimation of the advantages of carrying on all manufacturing processes as much as possible under one roof, and on one floor—great economy of time and labor would result, especially where heavy masses, such as parts of machinery, required to be moved about; he would always adopt the system in constructing a manufactory.

Mr. Smith observed that an arched roof would be found as cheap as one of wood and slates, and in the relative durability there could be no comparison.

Mr. Marshall desired it to be borne in mind that the cut stone front of the mill had greatly enhanced the cost, and that, being the first building of the kind erected in the neighborhood of Leeds, it had naturally been more expensive than others would be.

Civ. Eng. and Arch. Jour.

A Daguerreotype Experiment by Galvanic Light. By B. Silliman, Jr., A. M., *of the Department of Chemistry and Mineralogy in Yale College, and* Wm. Henry Goode, M. D.

In November, 1840, we succeeded in obtaining a photographic impression, by galvanic light reflected from the surface of a medallion to the iodized surface of a Daguerreotype plate. The large battery in the laboratory of Yale College, consisting of nine hundred pairs of plates, ten inches by four, was charged with a weak solution of sulphuric acid, and its poles adjusted with charcoal points, in the manner which is customary, when an intense light is to be produced by means of this instrument. Two pictures were obtained; one of which is made up of a blur, or spot, produced by the light from the charcoal points, the image of the retort-stand, on which a medallion of white plaster rested, and the image of the medallion, but the lines on its

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face are not given. The camera was about six feet from the charcoal points when this impression was taken, and the medallion a little on one side, and in the rear of the points. The plate was exposed to the light about twenty seconds, and no means were employed either for condensing the light on the objects to be copied, or that reflected from them, on the lens which gave the image. The only lens employed was a French achromatic, three inches in diameter, and of about sixteen inches focal length. Another picture was taken of the medallion only, which was placed about two feet from the charcoal points, and the camera about four feet from it, and in such a position that the charcoal points did not come within the field of the lens. This picture, we regret to say, has been inadvertently destroyed. The plates used were of inferior quality, being some of the first of American manufacture.

These experiments were not published at the time they were made, because it was understood that a gentleman, distinguished for his scientific investigations, was already engaged in studying this branch of the subject, with whose researches we had no wish to interfere, and the matter was abandoned mainly for this reason. Having been informed recently, however, that this gentleman had also abandoned it, we have concluded to give this account of our experiments.

On the same occasion, an observation was made respecting the image given by the two charcoal points, when they were nearly in contact, and the battery in full operation, which we do not remember to have met with elsewhere. An image of each charcoal point is given, separate from that of the other, by a lens placed at a little distance. These two images differ remarkably in color; one is of the color of the flame afforded by the combustion of an alcoholic solution of strontia; the other resembles, in color, the flame produced by the combustion of an alcoholic solution of chloride of sodium, more nearly than anything else with which we can compare it. The charcoal points were shifted, each to the opposite pole of the battery, without producing any change in the color of the light given off by the poles respectively. Other pieces of charcoal were substituted, in the place of those with which this phenomenon was first observed; but the difference in the color of the two images was always present, and did not seem to be connected in any manner with the particular charcoal points employed, but the yellow image was uniformly given by one pole, and the purple image by the other pole of the battery. We are under the impression that the yellow colored image was produced from the charcoal point in connexion with the positive pole of the battery, and that the strontia colored image came from the negative pole of the battery, though of this no note was made at the time. No attempt was made to ascertain, by direct experiments, whether these images possessed a different degree of power, or not, in producing an impression upon an iodized plate. The difference in their color was presumptive evidence that one image (that from the negative pole) possessed more of the chemical rays than the other. But evidence is (we are of opinion) afforded, indirectly, that such is the fact. The light from both charcoal points made a slight impression on the iodized

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plate, before they were brought so close together as to unite in forming a general blur: these two small spots, or impressions, are nearly opposite, or at each extremity of one diameter of the blur, and without its circumference; one of them is more distinct than the other. Within the edge of the blur, and nearly in the same diameter with the two spots above named, there are also two impressions, darker and more strongly marked than is the general impression made by the light from the points. One of these spots is doubtless made by the light from one point, while the other is due to the light from the other point, and one of them far exceeds the other in distinctness. Now, the more strongly marked spot without the blur, and the more strongly marked one within it, are close to each other, on the same edge of the blur, and are, doubtless, produced by the light from one and the same charcoal point. The two other spots, viz., that without and that within the blur, which are much less distinct, are close to each other at the opposite extremity of the diameter of the blur, and are also evidently produced by the light from the other charcoal point.

Yale College Laboratory, June 20, 1842. Silliman's Jour.

Metal Forging and Cutting Machine.

Although, at the late meeting of the British Association in Manchester, there were many very interesting specimens of mechanism exhibited, there was, nevertheless, one, in particular, which threw all others completely into the shade, when considered either as to the novelty of the invention, or its evident practical applicability to the every day concerns of life, and may with truth be said to have been "the lion of the exhibition," viz., a machine for the working or forging of iron, steel, &c. This truly surprising machine is quite portable, occupying only a space of three feet by four feet, and cannot be deemed other, even by the most critical judges, than one as purely original in principle, as well as practical in its application, as much so, perhaps, as was the splendid invention of the fluted roller of Arkwright, by which the art and perfection of drawing the fibrous substances became known, or that still more splendid discovery of Watt, the condensing of steam in a separate vessel, by which the power of the steam engine of that day may be said to have been doubled. But now for some explanation of the machine, and its probable general application. It is, then, as has before been said, very portable, not requiring more space than from three to four feet, and may be worked by steam or water power, and when moved by the former, as was the case at the exhibition, made 650 blows, or impressions, per minute; but from their very quick succession, and the work being effected by an eccentric pressing down, not striking, the hammer, or swage, not the least noise was heard. There are five or six sets of what may be called anvils and swages in the machine, each varying in size. The speed and correctness with which the machine completes its work is perfectly astonishing, and must be seen in order that its capabilities in this respect may be duly appreciated; for instance, when it

was put into motion for the purpose of producing what is known as a roller, with a coupling square upon it, (and which had to be afterwards turned and fluted,) the thing was accomplished in fifty seconds! of course at one heat, to the astonishment of the bystanders. But what appeared as the most extraordinary part of the affair, was, that the coupling square was produced direct from the machine, so mathematically correct, that no labor can make it more so! The machine will perform the labor of three men, and their assistants, or strikers, and not only so, but complete its work in a vastly superior manner to that executed by manual labor. For engineers, machine makers, smiths in general, file makers, bolt and screw makers, or for any description of work parallel or taper, it is most specially adapted; and for what is technically known as reducing, it cannot possibly have a successful competitor—in proof of which it may be stated that a piece of round iron, $1\frac{3}{4}$ inch in diameter, was reduced to a square of $\frac{5}{8}$ in., 2 ft. 5 in. long, at one heat. The merit of this invention belongs, it is said, to a gentleman at Bolton, of the name of Ryder.—*Leeds Merc.*

Lond. Mech. Mag.

Galvanic Gilding.

A German journal gives the following account of what it designates as one of those wonders in which electrical chemistry is so fertile:—"A pupil of Berzelius, who was occupying himself in Sweden with galvanic gilding, having used in his apparatus the skin of a sheep, on which there was some of the wool remaining, perceived that they became partially covered with gold. Struck with the incident, he followed up the idea it suggested, and in time produced an entire golden fleece, preserving the wool in its original and natural state, as to texture and flexibility. Living in a village, the young *savant* showed the wonderful production to his neighbors; but the fanatical and ignorant peasants, regarding him as a practicer of the black art, attacked his laboratory, broke all his utensils to pieces, and compelled him to fly with his fleece to Upsal, where he was received with kindness and consideration by the members of the University, who, by a subscription, not only supplied him with the means of subsistence, but established a new laboratory for him, and aided him in applying his new discovery to the manufacture of woolen cloth. We may, therefore, expect to have, shortly, cloths of gold, silver, and platina, which will entirely supersede our present gold lace and embroidery.

Lond. Athenæum.

Cast-Iron Buildings.

A correspondent of the Times says:—"Buildings of cast-iron are daily increasing, at a prodigious rate, in England, and it appears that houses are about to be constructed of this material. It is proposed that the walls shall be hollow, so that the whole house may be heated

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by a single stove in the kitchen. A three-story house, containing ten or twelve rooms, will only cost about £1000; and it may be taken to pieces, and removed to another place, at an expense of about £25. It is understood that a large number are about to be manufactured, to be sent to Hamburg, for those persons who have had their habitations burnt."

Ibid.

Phillips' Mineralogy.

W. D. Ticknor, of Boston, has in the press a new and considerably enlarged edition of this popular work; the text is from the fourth edition, as improved by Robert Allen. The American edition is edited by Mr. Francis Alger, Member of the American Academy, of the Boston Natural History Society, &c. &c., and will be rendered particularly acceptable and useful to the American mineralogist by the description of many minerals of our own country, not named in the original work, as well as of such foreign minerals as are of recent discovery. The high character of the original work is well known, and the qualifications of the American editor give assurance that the improvements in it will be real.

Meteorological Observations for October, 1842.

Moon.	Days.	Therm.		Baromtr.		Wind.		Water Fallen in rain	State of the Weather, and Remarks.	
		Sun Rise.	2 P.M.	Sun Rise.	2 P.M.	Direction.	Force.			
	1	53°	70°	29.90	29.90	W.	Moderate		Clear.	Clear.
⊗	2	58	70	29.70	29.70	W.	do		Fog.	Flying clouds.
	3	47	69	29.85	29.85	W.	Brisk		Clear.	Flying clouds.
	4	47	64	29.90	29.90	W.	do		Clear.	Clear.
	5	44	62	30.00	30.10	W.	Moderate		Clear.	Clear.
	6	43	59	30.15	30.20	NE.	do		Clear.	Clear.
	7	40	62	30.20	30.20	W.	do		Clear.	Clear.
	8	48	68	30.00	29.90	W.	do		Fog.	Clear.
	9	50	67	29.60	29.60	SW.	do		Cloudy.	Cloudy.
	10	46	60	29.80	29.85	W.	do		Clear.	Cloudy.
☾	11	41	64	29.80	29.70	W.	do		Clear.	Clear.
	12	44	66	29.70	29.80	W.	Brisk		Clear.	Clear.
	13	44	65	30.05	30.00	W. SW.	Moderate		Clear.	Clear.
	14	42	67	29.90	29.80	E. SE.	do	.40	Clear.	Rain.
	15	48	56	29.60	29.54	W.	Blustering		Clear.	Flying clouds.
	16	40	64	29.80	29.80	W.	Brisk		Clear.	Clear.
	17	49	62	29.90	30.00	W.	Moderate		Cloudy.	Clear.
	18	52	71	29.90	29.75	S. SW.	Brisk		Cloudy.	Hazy.
☉	19	44	56	29.95	29.90	W.	do		Clear.	Flying clouds.
	20	39	51	30.00	30.05	W.	do		Clear.	Clear.
	21	35	54	30.20	29.65	W.	Moderate	.15	Hazy.	Rain.
	22	39	59	30.00	29.86	W.	do		Par. cloudy.	Clear.
	23	48	55	29.80	29.85	W.	Brisk		Par. cloudy.	Clear.
	24	42	69	29.95	29.90	W. S.	Moderate		Par. cloudy.	Partially cloudy.
	25	60	54	29.66	29.60	SE. W.	Brisk	1.65	Rain.	Rain.
☽	26	40	52	29.86	29.90	NW.	do		Clear.	Clear.
	27	38	52	30.00	30.10	W.	do		Clear.	Clear.
	28	36	54	30.30	30.30	NE.	Moderate		Clear.	Clear.
	29	36	58	30.30	30.30	SW.	do		Cloudy.	Hazy.
	30	46	54	30.20	30.20	NE.	do		Cloudy.	Cloudy.
	31	44	54	30.25	30.25	E.	do		Cloudy.	Cloudy.
		44 64	60.93	29.94	29.92			2.20		

Thermometer.		Barometer.	
Maximum 71 on 18th. Minimum 35 on 21st.	Mean 52.785	Max. 30.30 on 28th & 29th. Min. 29.54 on 15th.	Mean 29.93

JOURNAL

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Civil Engineering.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

[CONTINUED FROM PAGE 11.]

Formulas and Tables for the Case of Mean Earth and Masonry.

15. The preceding considerations naturally lead us to investigate whether it would not be sufficiently exact, in practice, to substitute, at least to a certain extent, the formula (m) for the method of calculating the thicknesses of revetments by the rigorous equation (g) of number 7, which reaches the sixth degree (8) when we substitute for M and u their values in e; in each case a suitable value should be given to the factor or coefficient δ, by which the moment M is to be multiplied. But, to prevent uselessly complicating the necessary calculations for establishing the comparison between the results of one and the other method, we will suppose $\theta = \alpha$, or the exterior slope of the parapet to be parallel to the natural slope of the earth, which is ordinarily the case. Considering, moreover, in the same view, the case of mean earth and masonry, for which $\alpha = 45°$, tang. $\alpha = 1$, $p = \frac{2}{3} p'$, and in recollecting the conventions established in number 1, from which we have

$$a = \frac{h}{H}, x = \frac{e}{H}, m = \frac{b}{H}, u = \frac{h'}{H+h} = \frac{h+b-e}{H+h} = \frac{a+m-x}{a+1}$$

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we can transform, without difficulty, the expressions (*a*) and (*b*) of number 3 into the following:

$$M = \tfrac{1}{6} p \left[3 + 3u^2 + 2u^3 - 2\sqrt{2}(1+u^2)^{\frac{3}{2}} \right] (H+h)^3$$

$$P = \tfrac{1}{2} p (\sqrt{2} - \sqrt{1+u^2})^2 (H+h)^2$$

which gives for the mean length of the lever arm of pressure, the expression

$$\frac{M}{P} = \tfrac{1}{3}(H+h)\frac{3 + 3u^2 + 2u^3 - 2\sqrt{2}(1+u^2)^{\frac{3}{2}}}{3 + u^2 - 2\sqrt{2}\sqrt{1+u^2}}$$

which can again be put under the form

$$\frac{M}{P} = \tfrac{1}{3}(H+h)(1-u) + \tfrac{1}{3}(H+h)\frac{u + 3u^3 - 2\sqrt{2}u^2\sqrt{1+u^2}}{(1+u)^2}$$

in multiplying the numerator and denominator of the fraction by $3 + u^2 + 2\sqrt{2}\sqrt{1+u^2}$. The second term of this expression for the lever arm will always be a small fraction of the first term, which represents (fig. 1) one-third of the height BH, or $H + e - b$, against which the pressure P is exerted.

16. Giving, in effect, to u the various values which it can receive from $u = 0$ to $u = 1$; that is to say, from h' or GH $= 0$, to $h' = H + h$, or GH = GB, which supposes BH zero with reference to BG, or CG infinite; we shall form the following table, in which the values of the ratio of $(u + 3u^3 - 2\sqrt{2}u^2\sqrt{1+u^2}) : (1-u)(1+u)^2$, being that of the second to the first term of the above expression for the value of the lever arm of pressure, are represented by

$$U : \left[= \frac{u + 3u^3 - 2\sqrt{2}u^2\sqrt{1+u^2}}{(1-u)(1+u)^2} \right] :$$

Values of u.	Values of U.	Values of u.	Values of U.
0.000	0.0000	0.400	0.0889
0.033	0.0029	0.500	0.0751
0.050	0.0420	0.600	0.0591
0.100	0.0685	0.700	0.0430
0.200	0.0943	0.800	0.0273
0.250	0.0978	0.900	0.0146
0.260	0.0980	0.950	0.0046
0.300	0.0966	1.000	0.0000

$$\left[\frac{M}{P} = \tfrac{1}{3}(H + e - b)(1 + U) \right]$$

17. It will be seen by this table that the greatest value of U is below one-tenth, and corresponds very nearly to $u = 0.26$; so that, in

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taking the arm of the mean lever of pressure equal to $1.05\,(\mathrm{H} + h)\,\frac{1}{3}$ $(1-u) = 0.35\,(\mathrm{H}+e-b)$, the error will not exceed one-twentieth; the second member of this equation is equal to 0.35 of the height BH, against which the pressure is exerted.

If we wish to obtain results always slightly above, though differing very little from, the true ones, we should take $\mathrm{M} = \mathrm{P}.\,\frac{1}{3}\,1.098\,\mathrm{BH} = 0.3666\,\mathrm{P}.\,\mathrm{BH}$ for all the values of H and h. But it is evident that the coefficient of stability δ, adopted as the factor of M in the equation of equilibrium (g) of number 7, should vary with every hypothesis assumed, although only by a very small quantity.

18. Taking with M. Français, for point of comparison, Vauban's revetment of ten metres high, with a mean load of a parapet two metres high, and supposing that the foot of the exterior slope of the earth should extend to the outer face of the wall, we shall have (7) to determine δ the equation of equilibrium

$$\tfrac{1}{2}\,p'\,\mathrm{H}\,(e^2 - \tfrac{1}{3}\,n^2\,\mathrm{H}^2) + \tfrac{1}{2}\,p\,(e-b)^2\,(e + \tfrac{1}{2}\,b) = \tfrac{1}{6}\,\delta\,\mathrm{P}\,(1 + \mathrm{U})\,\mathrm{BH}$$

in which $n = 0.2$, $\mathrm{H} = 10$ metres, $e = 3.6$ metres, $p = \frac{2}{3}\,p'$, $b = \frac{1}{5}\,\mathrm{H}$ $= 2$ metres, and $u = \dfrac{h'}{\mathrm{H}+h} = \dfrac{0.4}{12} = \dfrac{1}{30}$, $\mathrm{BH} = 11.6$ metres, which gives $\delta\,(1 + \mathrm{U}) = 1.9173$, $\delta = \dfrac{1.9173}{1.0029} = 1.912$, by observing that in the foregoing table $\mathrm{U} = 0.0029$ answers exactly to the value of $u = 0.0333$ or $\dfrac{1}{30}$. If we should suppose, *a priori*, that the mean lever arm of the pressure is equal to 0.35 BH, or $\mathrm{U} = 0.05$, we ought, on the contrary, to take $\delta = 1.826$, &c.

19. It will follow from this, on the hypothesis of mean earth and masonry, and of the coefficient $\delta = 1.912$, that we shall have, for calculating x, the proportional thickness of the revetments, (15,) the equation

$$(n)\begin{cases} x^2 + \frac{4}{3}\,(x-m)^2\,(x + \frac{1}{2}\,m) \\ = 0.425\,(\sqrt{2} - \sqrt{1+u^2})^2\,(a+1)^2\,(x + 1 - m)\,(1+\mathrm{U}), \end{cases}$$

in which we shall substitute the values of U given by the above auxiliary table, for each of the particular values attributed to a, m, x, and u, (15) in recurring at need to the interpolation by proportional parts, or, otherwise, by tracing a continuous curve, having the valves of u for abscisses, and those of U for ordinates.

20. It is thus that we have formed by the method of successive approximations, the following table of the values of x, which are made on the hypotheses of $m = 0$, $m = 0.2$, $m = x$, embracing nearly all cases occurring in practice. For which hypotheses the equation (n) becomes respectively:

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$$x^2 + \tfrac{4}{3}x^3 = 0.425\left[\sqrt{2} - \sqrt{1+u^2}\right]^2 (a+1)^2 (1+x)(1+U)$$

$$x^2 + \tfrac{4}{3}(x-0.2)^2(x+0.1) = 0.425\left[\sqrt{2} - \sqrt{1+u^2}\right]^2 (a+1)^2 (x+0.8)(1+U),$$

$$x = 0.652\left(\sqrt{2} - \sqrt{1+u^2}\right)(a+1)\sqrt{(1+U)},$$

the corresponding values of u being:

$$u = \frac{a-x}{a+1},\quad u = \frac{a+0.2-x}{a+1},\quad u = \frac{a}{a+1}.$$

In this table we have also inserted:

1st, the values of x, which are deduced from M. Français' equation (l), which, from the foregoing notation and hypotheses, becomes

$$(o) \qquad x = 0.262\,(a+1)\sqrt{a+1};$$

2d, the values of x furnished by formula (m,) or

$$(p) \qquad x = 0.285\,(a+1),$$

the coefficient of which 0.285 has been calculated in such a manner as to reproduce, on the supposition of $H = 10$ metres, $h = 2$ metres, or $a = \frac{1}{5}$, the thickness of a vertical revetment of the same stability as that of Vauban, which thickness is 0.342 of H, or of its height.

3d. In fine, that which is given by formula

$$(q) \qquad e = 0.202\,(a+0.89)\,H + 1.24 \text{ metres},$$

this formula is deduced from Vauban's rule for demi-revetments, by the method of transformation of profiles, which will be given further on, but which supposes the transformed vertical wall to have a berme equal to $\frac{1}{5}$ of its height H.

It will be recollected, moreover, (6) that, in the case of figure 2, the foregoing equation (n) should be replaced by its corresponding one (k) of number 9, which gives here

$$x = \sqrt{\tfrac{1}{3}\,\frac{0.3281\,(a+1)^3 + (a+m)^3 - m^3}{a+1.5}}$$

the values of which should, consequently, be substituted for those which are deduced from equation (n) or its derivatives, whenever $h < e - b$, or $a < x - m$; which corresponds to $a < 0.415$ for the case of $m = 0$, or no berme, and to $a < 0.104$ for that of $m = 0.2$, or of a berme equal to $\frac{1}{5}$ H.

These limits will be indicated in the fifth and sixth columns of the following table, by horizontal lines drawn under the quantities.

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Comparative Table

Of the Thicknesses of Vertical Revetments sustaining high embankments, deduced from Formulas (n), (o), (p) and (q), relative to ordinary earth and masonry.

Value of a or $\frac{h}{H}$	Deduced from the profile of Vauban, or equation (q)	From Formula (o)	From practical formula (p)	From exact form'a (n) berme b'ng Zero.	Equal to 0.2H	Eq'l to the thickness.
	metres.					
0.0	0.180H+1.24	0.262H	0.285H	0.270H	0.270H	0.270H
0.2	0.220H+1.24	0.345H	0.342H	0.336H	0.342H	0.326H
0.4	0.261H+1.24	0.434H	0.399H	0.399H	0.405H	0.358H
0.6	0.301H+1.24	0.530H	0.456H	0.477H	0.457H	0.377H
0.8	0.341H+1.24	0.633H	0.513H	0.544H	0.504H	0.391H
1.0	0.382H+1.24	0.751H	0.570H	0.605H	0.540H	0.405H
2.0	0.584H+1.24	1.361H	0.855H	0.795H	0.655H	0.425H
3.0	0.786H+1.24	2.096H	1.140H	0.892H	0.717H	0.435H
4.0	0.988H+1.24	2.929H	1.425H	0.957H	0.755H	0.442H
10.0	2.200H+1.24	8.568H	3.135H	1.109H	0.839H	0.452H
20.0	4.220H+1.24	25.213H	5.985H	1.171H	0.872H	0.456H
Infin'e	Infinite	Infinite	Infinite	1.243H	0.927H	0.461H
1	2	3	4	5	6	7

Observations and Consequences.

21. This table leads to several important consequences. It will at once be seen, by the last three columns, that the thicknesses of revetments increase proportionally to their heights, when the inverse ratio a of these heights to those of the loads, does not change. Besides, the numbers at the bottoms of these columns show that the thicknesses of revetments converge to a finite, and, indeed, a small, limit; while, on the contrary, the height of the load approaches infinity with reference to that of the masonry—a fact worthy of being remarked, and entirely analogous to the one presented by M. Petit for the thicknesses of the buttresses of arches.

In fine, the comparison of the numbers of these same columns, which belong to equal values of a, leads to another fact, which would appear odd, if we were to overlook the reciprocal influence of the weight of the earth, CIH, (fig. 1,) which rests directly on the wall, and the pressure of the other earth against it, along the section, CH, formed by the upward prolongation of the plane of the back of the wall: it is, that the existence of a slight berme, which, for light loads, with reference to ordinary revetments, gives a sensible excess to the thickness of the masonry, will, on the contrary, lead, for high embankments, exceeding four-tenths of the height of the wall, to a diminution of the thickness, which constantly increases with the height of the load, and the width of the berme.

22. Now, if we compare the results of the second, third and fourth

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columns of the table, with those which correspond to them in the fifth, sixth and seventh columns, of which the first two express, on our hypotheses, the true thicknesses of vertical revetments, with such widths of bermes as comprise nearly all practical cases; we conclude from it, that, at least for mean earth and masonry:

1st. The rule of Vauban gives thicknesses which surpass as much more those which it would be sufficient to adopt for the stability relative to rotation, as the height H of the demi-revetment, is smaller with reference to the height h of the load of the parapet; but it can also happen that it might give too slight thicknesses for great values of H.

2d. The formula (o), which, for very small loads, gives rather short results, afterwards leads to excess in the thickness, which excess rapidly increases with the ratio, a, of the height of the load to that of the wall; and if, with the view of lessening its influence, we substitute, as is ordinarily done, for this first height, taken simply from the middle of the superior slope of the parapet, a less one, we then fall into arbitrary results, without preserving the certainty of being always above the true dimensions.

3d. The empirical formula $e = 0.285\ (\mathrm{H}+h)$, gives thicknesses which, although a little too great for small loads, are generally comprised between those of the fifth and sixth columns, as long as the height of the load does not materially exceed that of the wall. More over, in no case can it lead to errors which exceed one-seventeenth of the total thickness, if we do not extend its application beyond this limit, and if we only consider the width of the berme to be the same as is usual in fortifications.

4th. In fine, none of the abridged rules nor formulas in question can answer in the case of very wide bermes, or of revetments, when the exterior slope of the parapet does not extend so as to cover a certain quantity of the top of the wall; the excess in the thicknesses given by these formulas over the true ones, increases as much more rapidly as the height of the load is itself greater with reference to that of the scarp.

23. We see from this that the formula $0.285\ (\mathrm{H}+h)$, notwithstanding its extreme simplicity, gives, in fact, less uncertain thicknesses than those got from the formula of M. Français; and these results, except in the specified case of very great loads or wide bermes, can be adopted with confidence, if it is allowable to admit, as is sometimes done in the application of formulas, that the earth and masonry are usually such as are called mean (15).

Now, there does exist, for one and the other, very marked differences; also the relative density and friction play so important a part in the thicknesses of revetments, that it would be exposing ourselves, at times, to serious mistakes, not only in adopting a like hypothesis, but perhaps in further admitting, without previous verification, within assigned limits, the exactness of the more general formula (m) of No. 13—the coefficient δ of which formula ought, evidently, to be taken so as to fall back upon the preceding one, on the hypothesis of

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$\alpha = 45^\circ$, and $p = \frac{2}{3}p'$; which gives simply, for the case of rotation: $\delta = 2.13$, and

$$(r) \qquad e = 0.845 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}\,(\mathrm{H}+h), \text{ or}$$

$$x = 0.845 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}\,(1+a).$$

24. Moreover, we are not ignorant that experienced engineers have believed that they might, for cases without superincumbent loads, or with very slight ones, adopt the rule which consists in taking, generally, the thickness of retaining walls equal to one-third of their height, (see numbers 84, and following, of this section;) but this rule, which agrees approximately with that deduced from Vauban's mean profile (20), which is generally considered as the type of the most exact proportions between the power and the resistance, leads, evidently, to excess of thickness in the case of light earth and very dense masonry, as it can also, on the contrary, compromise the solidity of constructions.

Let one, in fact, read, in the "*Annales des Ponts et Chaussées,*" year 1831, pages 62 and 349, two very short articles, the one by M. Navier, the other by M. Gayant, concerning a very interesting discussion which arose upon the thickness to be given to the wall of the quay of the outer port of Dieppe; and it will be seen that it is absolutely necessary, in certain cases, to take into consideration the nature of the earth and masonry, if one wishes to shun the inconveniences in question, and which are inherent to every invariable and empirical rule of the kind which we have just noticed, without even excepting that deduced from the profile of Vauban.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 28.]

The tastes and speculations of the last fifteen years have been so exclusively devoted to railways as the fashionable mode of internal communication, that canals have been almost lost sight of; and it is now nearly forgotten by the modern speculator, though it may be interesting to the young engineer to be informed, that, fifty years ago, the mania for constructing canals and improving river navigation was as great, even if not greater, than the enthusiasm displayed very recently about railways. Parliament was then deluged with applications to grant acts of incorporation for canal companies; the press teemed with canal publications, the shop windows were filled with canal maps and sections, and the papers and periodicals with advertisements and paragraphs on canalization.

Canals appear to have been duly appreciated in ancient times, and used for the purpose of drainage, irrigation, supply of water, and nav-

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igation. In his former introductory lecture he alluded to the canal of Xerxes, at the foot of Mount Athos—an attempt which is stated to have been renewed by the Roman emperors in later ages. A canal navigable for large boats was constructed by the Ptolemies between the Nile and the Red Sea, though it is doubtful whether the state of engineering skill in those days permitted an actual junction to be made; this grand navigation was re-opened by the caliphs in the seventh century. Traces of it are still existing, and its termination in the most easterly branch of the Nile was discovered by M. Boutier, in 1707, and is still open. Under the enterprise of the present ruler of Egypt, it may yet fall to the lot of an English engineer to re-open this magnificent canal. Herodotus assures us that the Nile was in itself, or by lateral canals, navigable by the ancient Egyptians for 500 miles above Alexandria, and the Delta of the Nile was formerly, like modern Holland, filled with canals. The Romans made more than one canal in England; the most remarkable was that called the Caer-dyke, which united the river Nene, a little below Peterborough, with the river Witham, three miles below Tiverton; it was forty miles long, and, fifty years since, appeared distinct enough, and must have been originally very deep; and what led to the impression that this canal was used for the purpose of internal communication, was, that there was a continuation of this canal from Lincoln to the Trent, above Gainsborough, by the Foss Dyke, which is at the present time a fine, navigable canal, though, in former times, it had been repeatedly filled up and gone into disuse. It is believed, on good authority, that by these two canals, the favorite colony of the Romans at York received their chief supplies of grain. The canals of China have always excited great interest since the description given of them by the Jesuit missionaries; their accounts, as far as regards the Great Canal running from north to south, (connecting, except at one short portage, Canton and Pekin,) have been completely confirmed by modern travelers, particularly by Barrow, who traveled the whole length. Should the existence of the numerous lateral and other canals over the rest of the country be confirmed, of which there is little reason to doubt, it will sufficiently explain the non-existence of anything like good roads, and the almost total absence of wheeled carriages for goods, to which the diminutive and bad breed of horses in China, no doubt, contributes. There is, however, a wide field opening in that country for the exercise of the skill of an enterprising engineer, since that ingenious people are as yet ignorant of the modern lock for their canals, and, when two canals meet, the difference of the level is sometimes from fifteen to twenty feet, and the boats are hoisted from the lower canal, up an inclined plane of smooth masonry, by capstans, and slide down another into the upper canal. The Professor stated it would lead him too far to go much into the history of canals; but he must allude to the great canals and inland water communication of the Mogul country, in the East Indies, made by the emperors 500 or 600 years since, for which the natural features and vast rivers of Hindostan afforded great facilities, and rendered lockage unnecessary; and, indeed, roads were unknown, and may be considered as still

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wanting, all over India, excepting our recent military roads. This country presents a vast field for the civil engineer. Of all the canals of modern Europe, he would only notice two remarkable instances: J. Perry, an English civil engineer, was employed by Peter the Great, in the beginning of the last century, to design and execute several canals, in which the German military engineer, (Brockel,) who had attempted them, had entirely failed; Perry's designs were subsequently completed by Peter's successors. The canal of Trolhatta, in Sweden, the difficulties of which had long baffled the engineers of that country, was finally completed by the skill of the late Mr. Telford, whose engineering resources were equally displayed in the design and execution of the Caledonian Canal. Many remarkable instances of success in making an imperfect river into a good navigable stream, might be quoted, both in Europe and North America, and which present instructive instances to the young engineer. The improvement of the river Liffey at Dublin, and the river Clyde in Scotland, are good examples. The improvement of that vast inland gulf, the Shannon, is now in the course of execution, after several years of most detailed and elaborate inquiries, estimates, surveys, and careful examination, the accounts of which may be studied with great advantage to both the experienced and the young engineer. Upwards of half a million sterling is to be expended on this truly national undertaking. The learned professor then entered into a long account of the probable original ideas for the application of iron to roads, commencing with the wooden railways used in the collieries on the banks of the Tyne, near Newcastle, above two hundred years ago; he then showed that the waste of timber led to the idea of covering wood with plates of iron, and ultimately to the present point of perfection—wrought iron rails—the introduction of which into general use does not extend further back than thirty years.

In the ensuing lectures he should endeavor to illustrate the following points—1st. The principles on which railways should be laid out under various circumstances of traffic, and topographical feature. 2d. The comparison of different systems of inclinations, or gradients. 3d. The analysis of the advantages of various breadths, or gauges. 4th. The illustration of the different modes of forming the railway proper, or upper works. 5th. The investigation and explanation of the great works of construction, as peculiarly found expedient in forming railways. 6th. The practice of framing estimates, and the necessary details connected therewith. 7th. The consideration of the various modes of working railways by animal and by mechanical power, locomotive and stationary. 8th. The inquiry into the working expenses and annual charge on railways; and concluding with a summary lecture, in which the general features of the course will be given, and drawing such prominent inferences as might be most useful and interesting. The other branches of internal communication, as well as the various and numerous subjects connected with the theory and practice of a civil engineer, must be taken up on other occasions. Reserving, then, the elucidation of the details under the several preceding heads for the class room, he would proceed to make

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a few general remarks. Of these, the most prominent and most important, in his judgment, and most to be impressed upon the mind of those about to enter the profession of a civil engineer, was that connected with the great excess of actual expenditure, in the construction of railways, over estimates; for not only has that unfortunate, and almost invariable, occurrence brought discredit on each concern so affected, but it has paralyzed, and will long continue to paralyze, the most honest and well-grounded schemes for further internal communication in general, and of all improvements, the cost of which is dependent on the engineer; and though each case ought to be tried and judged on its own merits, the public confidence appears gone, and the capitalist observes with a sneer, "You engineers are all alike; we can trust none of you." Now, without shrinking from his own individual share of the odium thus cast upon the profession, as far as it may truly be deserved, the Professor denied the general and sweeping imputation; and he called on the directors of public companies, in justice to themselves, to their subscribers, to their own engineers, and to the public in general, to publish such details as would exonerate his profession, and leave it charged with no more than what was attributable to it. He called upon his brother engineers to follow this out, by furnishing their quota of information. Let the public in general know these details as matters of railway statistics of the highest interest—let the profession know them as matters of precedent of the most valuable kind—and let the capitalist be undeceived as to his present impressions of mistrust. Quite independent of any financial difficulties—quite independent of any standing orders or regulations of Parliament—a man might as well cry "mad dog" as talk of a new railway speculation, or a water-work, or, indeed, any public undertaking, where the function of profits is a certain known quantity, but dependent on estimates which are considered visionary, because "all engineers are alike in this respect." Let, then, the young engineer mark well the bitter lesson the oldest engineers are now learning—let them cause the most assiduous inquiry into the details—the most unremitting toil in gathering information—storing their minds, exercising their memories, practising their hand, and working out their calculations—let them remember that, by working drawings, by models, and by every *a priori* means of unceasing investigation, they must "first and truly calculate the cost" of what in future life they may be called upon to undertake. If the matter be ever so trifling, they must not shrink from the truth, or attempt to disguise it from themselves, still less from their employers. Let them never have it said of them that they had whispered among themselves, "Oh! it will never do to tell the directors what the work will cost, or it will never be entered upon"—a remark which he had heard fall from an eminent engineer; nor let them indulge in the vain hope of future fame, by taking as their text the observation attributed to another engineer of the very highest and well-deserved reputation—"A century hence there will be no one who will ask what this work cost; they will only inquire who did it."

He begged to repeat, then, what he stated at his first introductory

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lecture, that the constant maxim the young, as well as the old, engineer should keep before him, is—"That the success of an engineer, in this country of private enterprises and individual exertions, depends, not upon the beauty, or the cost, of his constructions, or as mere works of art, but on their success as profitable and mercantile speculations." They must not suppose this to be an ignoble maxim; it must be followed out to its true results, and then they would find that prudence, caution, economy, judgment, and the highest intellectual gratification, follow closely in its train; for, to apply the words of Mr. Booth, the intelligent secretary of the Liverpool and Manchester Railway, and one of the fathers of the modern railway system—"The contemplation of what is passing in England, (alluding to the first cost of railways,) must not be without its lesson; for, in all countries, and under all circumstances, it is an object worthy of a statesman, to prevent the reckless waste of the national means, and to give a right direction to the public expenditure." And shall it be said that it is not equally worthy of an engineer? What are the aggregate subscriptions of associated and incorporated bodies of individuals but great portions of the "national means," which should not be wasted by the statesman or by the engineer? What are the monies invested in railways but a part, and, in the United Kingdom, a most important part, of the "public expenditure?" And is it not at once the duty, as it ought to be the pride, of an engineer, to give that expenditure a "right direction?" Let the maxim he had laid down be duly followed out, and that duty would be accomplished. The learned Professor continued by stating that, even at the risk of having motives attributed which he should be unworthy of public or private estimation if he entertained for a moment, he would call the attention of the student to an instance of great expenditure on railways. The perfect completion, in the manner contemplated, of the internal communication by railway from London to the Sussex coast, a distance of little more than fifty miles, will amount, in the aggregate, to nearly four millions sterling. Is not that a reckless waste of the national means? Is that a right direction of public expenditure? Will not the public, in some way or other, pay for that?—the subscriber, or the traveler, or both? To quote the words of an intelligent and experienced railway man—"With such results before us, would it not be almost criminal not to endeavor to secure the advantages of a better system?" The average cost of the railways in England has been very nearly £30,000 per mile. The cost of future lines must not be more than one-half of that sum, or it may be considered that there is an end to the extension of the railway system. The Professor stated that it would be his attempt to explain, in the course of his lectures, his ideas that such a reduction in the expense might easily be made, and he would show that they were founded upon practical experience. The profession would be greatly aided, and the public vastly benefitted, if the railway companies and their engineers would publish the detailed accounts he had asked for, to serve as a beacon, for which all would be very grateful; and it was his deliberate opinion and recommendation, that, if they would not do so, Par-

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liament ought to give the railway department of the Board of Trade powers to enforce such returns.

The total amount of capital invested in the railway speculations of this country is probably little short of £50,000,000, and the total extent of lines about 1700 miles—most of which are now completed. This may be said to be the creation of the last fifteen years. The total length of navigable canals in Great Britain is nearly 2500 miles; they were chiefly formed in the last forty years of the preceding century. The capital invested in this branch was about £20,000,000, with an annual expense of about 50*l.* per mile. In addition to canals, there are about 1500 miles of navigable rivers. The turnpike roads of England and Wales are stated, in official returns, to be nearly 20,000 miles in extent, executed at an expense of at least £20,000,000, and maintained at an expense of about £1,750,000 per annum, and all formed within little more than a century, exclusive of other highways, in length about 100,000 miles, with an annual expense of 12*l.* or 13*l.* per mile, or 75*l.* per mile, for maintenance. The extent of executed railways in the United States of America appears to be about 4000 miles, executed within the last fifteen years, at a cost of about £8,000,000, or about £5000 per mile; most of them are single lines, and it is stated that the average net income has been about five per cent. per annum. The extent of railways in Belgium is now about 200 miles, executed at a cost of rather more than £1,500,000, or about £8000 per mile; most of these are single lines, and have all been executed within the last ten years.

The average annual expense of maintaining the railways of England, (exclusive, of course, of moving power, carrying and managing establishments, &c.) appears to be from £200 to £300 per mile, per double way; but on the Dublin and Kingstown Railway, where the system of longitudinal timbers for the upper works has been completely carried out, the same heads of expense are now reduced to less than 50*l.* per mile per annum, with a locomotive traffic over that railway as great, if not greater, than over any one in Great Britain. The average expense of the canal maintenance in this country seems to be about 50*l.* per mile per annum.

The Professor concluded by stating that he would close his somewhat desultory discourse by calling attention to the fact, that the first elements of the amelioration of internal improvements, he would not say internal communication, which arose in this country, date from the period of the introduction of the Poor Laws into England, the effect of which has been to compel the rich to find employment for the poor, or to support them, and thus has been carried out the great principle of self-dependence, in separate districts, to work out their own improvements. Certain it is, that, from the passing of the act of Elizabeth, which instituted a legal maintenance for the destitute, and, by making mendicity a crime, swept the hordes of beggars, idlers, and sorners, from the face of the land, this country took a start, and, overtaking in improvement the other states of Europe, then far in advance of her, has since pursued that successful and continued march of amendment of her internal communication, which forms so remarka-

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ble a feature of England, proving her wisdom, and proclaiming her prosperity. He begged that, with his previous cautions, the students would remember that the agent for the carrying out of such improvements, past and to come, has been, and he trusted long would continue to be, the civil engineer.

(To be continued.)

Facts and Observations on Four and Six Wheel Engines.

By John Herapath, Esq.

[Continued from Page 47.]

It will be seen that I have been on thirteen of the Great Western Railway engines. They certainly are fine, powerful engines, and are able to attain very great speeds, with loads that many other engines would find a difficulty in drawing at even moderate velocities. I have heard, in one case, of ten miles having been done by one of them in nine minutes, or *at the rate of* 66½ *miles per hour.* Their large boilers and capacious cylinders give them a power which no other engines possess, and their lofty 7 feet driving wheels enable them to use this power with great advantage at high speeds. But, on many of the new engines, I observe they have only 6 feet driving wheels. Whether that arises from the alleged difficulty which the 7 feet wheels sometimes experience in starting their loads, and clambering up the two inclines, especially the Box, I am unable to say; *but it is a fact on which no doubt exists, that, in getting up inclines with heavy loads, small wheels have a decided advantage over large.* There are cases, indeed, in which a large wheel would not move a load with which a small wheel would trip off merrily. But, with such a load as a large wheel can take well, and at a high speed, there can be no question of the advantage being all on the side of the larger wheels. Upon this line, I understand, it is found that the working of the large wheels is manifestly more economical.

The platform of the Great Western locomotives, in comparison to the platforms of the other companies' engines, is like the quarter-deck of a first rate line of battle ship; and the lofty, square, and roomy fire boxes are exceedingly comfortable for the men, who can get behind them, almost entirely screened from the wind and weather, and still keep a good look out. In consequence of the great breadth of the gage, they have also been enabled to place a platform, by which the men can walk round the engine, while going on, and do anything that is wanting. Had these engines a little sheet iron about the railing of the platform, they would be the most warm and comfortable engines for the men of any upon either of the railways on which I have been. As it is, there is very little to complain of. With ample room, and nearly as much protection from the wind and weather as it is possible to afford, the men ought to be, and I believe are, very well satisfied.

From the great length, breadth, and weight of these engines, as I have before observed, they keep their legs; and I am not aware of any case in which, when thrown off the rails, they have upset. Like

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sturdy giants, they maintain their feet, whatever foes oppose them. But, with all these good qualities, I cannot say I am an admirer of their motions. I have observed more rolling and pitching in these locomotives than in almost any engines on which I have traveled; and their lurches and plunges, if the engine is a little out of order, when going at a high speed, are almost awful. Nor am I alone in this opinion. Men to whom I have spoken, who have had experience with these and other engines, think of them as I do, and would prefer one of the tight little four-wheel engines to any of the Great Western.

Their vast weight, two or three and twenty tons, at high velocities, must occasion great wear and tear to themselves and the road; as some of the men quaintly expressed it, "they kill themselves by their weight." The injurious effects of this ponderous load of engine metal and timbering appeared to me to be very manifest from this fact, that every engine on which I rode, that had been out but a few months, exhibited great symptoms of wear and excessive strains. In some, the driving wheels were as much as half, or three-quarters, of an inch out of truth; in others, the framings appeared much strained and shaken; and all which had done much work, were very loose in the brasses. So very marked did these cripple qualities appear to me, that at first I thought they had not a good tight engine upon the line, and imagined, like the man with the short neck, they must have been born so. But, by close observation, I found that these groggy qualities were almost always in proportion to the work the engine had done, and that their engines which had been but recently out were as tight and right as other people's. I was therefore forced to the conclusion that the Great Western engines, either from their weight, or the breadth of the way, or perhaps both together, wore faster and more than they usually do upon other railways. By a reference to facts, I find this to be the case. On the Manchester and Leeds, with their very heavy gradients, the cost of repairs to the engines was 2.62d. per mile run to the end of June last; on the London and Birmingham, 4.17d.; and on the Great Western, 4.6d. In this comparison, it must be borne in mind that the Great Western has by far the best of it, in gradients and curves, of either of the other lines; and in respect of the London and Birmingham line, the advantage is also considerably on the side of the Great Western, in having been more recently opened, and, consequently, having newer engines to work with. Two or three years hence, things will be more on a par, and the amount of repairs will become more apparent. In confirmation of my opinion hereon, I make the following extract from a letter I have just received from a gentleman practically engaged with locomotives:—"I take great interest in your account of the Great Western—*I may be wrong*, but, from what I saw of the construction of some of their engines in Lancashire, some weeks since, *I think* they have *an awful day of reckoning for repairs to come.*"

Every thing on this line is upon an enlarged scale. Their gigantic engines are followed out by a superior size of the carriages. The Great Western first-class carriages are almost traveling houses, and,

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in comparison with the carriages of other companies, seem to have been destined for a different race of mortals. This company have been as prodigal of room as many of the others have been niggardly. After having traveled much in a Great Western first-class, one feels by no means at ease within the contracted limits of other carriages. Many observations have I heard, in the course of my travels, of the superior capacity and comfort of the Great Western carriages over all others. So frequent has this been, that I thought, once or twice, whether this company ought not to be proceeded against as general defamers, not in word but in deed, of other companies' concerns. For it is a fact, that they have occasioned more grumbling and fault-finding on other lines, than all the blunders and accidents put together. "What little poking holes these carriages are," quoth one, "in comparison of the Great Western." "Aye," says another, "they do well upon that line. One can walk, stand, sit, or lie down as he pleases in a Great Western carriage." "There ought to be an Act of Parliament," rejoins a tall third, "to compel other Companies to make their carriages as comfortable and roomy as the Great Western. One has not room to put his legs here."

It is to be regretted that they have not maintained the same superiority in their second-class carriages. I say maintained, because it is a fact that the Great Western second-class carriages were originally really very comfortable vehicles, having closed up sides and glass doors, like the Grand Junction: but it seems they were too good for the first-class.

Though no one can help admiring the Great Western first-class carriages, it is a matter for consideration at what extra expense to the Company these comforts are purchased. I remember once to have measured the front area of one of these first-class carriages, and found it nearly 62 square feet, exclusive of the wheels. At 40 miles an hour, therefore, the resistance of the atmosphere increases the draft by at least 46 tons extra load upon the first carriage, and taking the whole train, probably by 50 per cent. more. It is therefore, as observed, worthy of consideration, whether this great comfort may not be purchased at too dear a rate. A few years' experience, as I have said before, will be the best proof.

Experiments have taken place during the whole period of the Great Western Railway, in one way or the other. Some were trying, when I was at Bristol, upon the making of coke, but with what result I have not heard. There has been a considerable saving in the price of coke, and some in the consumption of it in the locomotives. For instance, in 1840 the engines consumed 50 lbs. to the mile, at a cost of 38s. 6d. per ton; but in the present year they are only using 46 lbs. at 31s. 7d. per ton. The saving in the consumption has been by putting lap to the valves, and that very lately. With both things, that is, the lap and reduction of price, the saving has been in the ratio of 1,925 to 1,443, or pretty exactly 25 per cent.

Not long since I have heard that an experiment was tried upon this line of eighty miles run. The engine, with its coke and water, weighed 23 tons, the tender 14, the load of the carriages and their

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cargo 70 tons, making a gross total of 107 tons, and the whole was taken at an average speed of 27 miles an hour, at a consumption of 45 lbs. of coke per mile. The load on the leading wheels of this engine weighed 7½ tons, on the driving 9½, and on the trailing wheels 6 tons, which is about the general proportion of distribution of weight in the Great Western engines.

Some experiments have also been tried with Craig's rotary engine, that is, an engine on the old, or Hiero's, principle, with a view to its application to locomotives; but, though I have an outline of an experiment thus made last summer, I have not heard that there is any chance of its being applied to locomotives.

The following is a comparison of a few of the parts of the Great Western engines with Bury's, Stephenson's old engines, and his last patent engine.

	Great Western 6 wheel.	Bury's 4 wheel.	Stephenson's 6 wheel eng's New.	Stephenson's 6 wheel eng's Old.
Diameter of cylinder,	14 & 15 in.	12 in.	14 in.	12 in.
Length of stroke,	18 in.	18 in.	20 in.	18 in.
Diam. of driving wheels,	6f. and 7f.	5½ feet.	5½ ft.	5 ft.
Distance between extreme axles,	13f. 2 in.	5½ feet.	10 f. 8 in.	10 ft.
Distance of centres of cylinders,	3 ft.	1 f. 10½ in.	2 f. 4 in.	2 ft. 7 in.
Distance between bearings on driving wheels,	4f. 7in. inside, & 8f. 6 in. outside.	3 ft. 3 in. inside bearings.	3 f. 10 in. inside bearings.	6 ft. outside bearings.

Square Feet of Heating Surface.

	Great Western 4 wheel.	Midland Counties 4 wheel.
In fire-box,	97 feet	47
In tube surface,	699	441
Dimensions of posts,	11 × 1¼ wide	steam 6½ × exhaust 6½ × 2½
Length of connecting rod,	5 feet	5½
Diameter of leading wheels,	3½ and 4	4

This company have 107 engines, all six wheel. They are almost all built on the same pattern, and have 6 or 7 feet driving wheels. Their average weight, loaded, is about 22 or 23 tons, and 14 tons the tender, with its complement of coke and water. Of these engines, I was assured by three different persons, there were not more than 40, or, at the outside, 50, at any time, in an efficient state, and able to take a train. The consumption of coke is about 46 lbs. to the mile,

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and the steam pressure which I observed in most was 55 lbs. to the inch. I believe, however, on some engines they work with a higher, and on others a lower, pressure; but 55 lbs. was what the valve was screwed down to in those I noticed, and I was informed it was the general pressure.

The following are the returns which I have received from the company. The number of engines is about 100, all six wheel, from 19 to 21 tons weight, loaded with water and coke. On the driving wheels the weight is from 8½ to 9 tons, and nearly balanced on the leading and trailing wheels, that is, about 5¼ or 5½ on each of the other pair. Of their engines, almost all are in a fit state to take a train. The play of the wheels on the rails is about ⅝ inch; the pressure worked with 50 lbs. to the inch; the cost of the engines from £1800 to £2000; consumption of coke 31 lbs. per mile for passenger engines, and 40 lbs. for goods; and the total expense of locomotive power about 15d. per mile; but it has been more, and is decreasing. The distance between the centres of the cylinders is 2¼ feet, and the engines do not work expansively. Their engines have no particular kind of motion when the road is good. They have no top-heavy engines. Some of the goods engines are coupled, and work very well, and all the engines have flanches on the driving wheels. The gross average load of the passenger trains, including engines and tender, is 116 tons, and of goods from 300 to 400 tons.

The extreme length of the frame of the engines is 22 feet, and 13 feet to 13½ feet the distance of the extreme axles. The driving wheels are 6 feet and 7 feet diameter, but chiefly the latter; the other wheels are 3½ to four feet; cylinders, 14 to 16 inches diameter; and stroke 18 inches.

They have had very few detentions from derangement or failure of machinery, and only five or six broken axles, one from defective welding, the rest from bad iron. Two or three of these fractures have been in coupled engines. In all these cases they were unable to proceed with their trains, but no accident happened to any one. They have had no engines run off the rails.

(To be continued.)

A few Statistical Facts on the Revenue and Expenditure of the two most expensive long, and two moderately expensive Railways. By John Herapath, Esq.

At a time when so much is said upon the question of good and bad railways, and when traffic and expenditure are matters of warm discussion, I have thought a few calculations and observations on the recent reports may not be unacceptable. For the purpose I have in view, I have selected two of the most costly long lines, the Birmingham and Great Western, and two of those which are considered reasonable in their cost of construction, namely, the Grand Junction and South Western.

It will be seen that, in my comparisons, I have had labor which has not been lessened by the very dissimilar manner in which the

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companies keep their accounts; but, if it will at all aid those to form sounder notions who are anxious to embark in railway property—for I can hardly expect it will be of much service to old railway stagers —I shall consider that my time has not been misspent.

I trust that my readers will distinctly bear in mind that my computations are based upon the data furnished by the last reports of the companies, for the genuineness of any of which data I do not hold myself answerable. If there has been any cooking in any of the accounts, the sin of it is none of mine. All that I hold myself accountable for is the calculations, which I have endeavored to make, and which I hope will be found, correct.

By the last half-yearly reports of the London and Birmingham, Grand Junction, South Western, and Great Western, Companies, the amounts called up in shares and loans, excluding shillings and pence, are—

	Lond. and Birm.	Grand Junction.	South Western.	Great Western.
Shares,	3,615,897	1,780,490	1,825,507	3,009,311
Loans,	2,278,654	483,362	630,100	3,332,025
Totals,	5,894,551	2,263,852	2,455,607	6,341,336

This is what I consider pure capital, disentangled from other items with which the accounts are encumbered. For instance, in the London and Birmingham account is a sum of £9,561 for "premium realized on the reserved new £32 shares," which, though put into the capital account, appears to me to be more of a contingency than, *bonâ fide*, a part of the capital. Again, in the Grand Junction, there is about the same sum made up of sale of refused shares, and of materials which, not having included at the time I made the calculations, though the sale of the refused shares forms certainly a very legitimate element of the capital, is not comprehended in the above statement. So £24,449, made up of "profit on shares," and "interest," carried to capital in the South Western, I have not called part of the capital, for the same reason as in the London and Birmingham, namely, that it appears to me to be a kind of accidental windfall, rather than legitimate capital. The same might be said of about £3000 in the Great Western account, for "registration fees" and "rents." This company is the only one of the four which does not exhibit a capital account, but gives simply a balance sheet of receipts and expenditure, including the half year's traffic and expenses. In the South Western, £296,545 belonging to the Gosport Branch is at present tantamount to a loan, having only 5 per cent. interest now paid on it. In August next it will be converted into shares, and receive a dividend. At present, however, it diminishes the share capital, and augments the debt, of the company, from 27.15 per cent. to 60.60, as in the following summary:

Thus, for every £100 of actual capital raised by shares, the

London and Birmingham	have severally	£63.03
Grand Junction		27.15
South Western		34·52 or 60 60
Great Western		110.72

of borrowed money taken up either on mortgage or loan notes. It appears, therefore, that an amount of debt nearly equal to two-thirds of the entire property of the shareholders stands against the London and Birmingham Railway; and a debt of something more than a fourth of their property against the shareholders of the Grand Junction; and in the South Western, of above a third; while in the Great Western the debt exceeds, by nearly eleven per cent., the whole property the shareholders have in the concern. It is not for us to say whether the legislature did, or did not, contemplate such very large debts as are here contracted. Fortunate, however, it certainly is, that in the first, and particularly the last, of these lines, that their per cent. profit upon the whole capital and debt together, exceeds that of their debt; for, were it otherwise, the shareholders would be in a most melancholy position. As it is, it is a great advantage to them to be in debt, and we should recommend them to keep so as much and as long as they can.

The Grand Junction have, by a little dexterity, reduced their capital to only £2,203,300. For, finding their shares at a high premium, they very adroitly hit on an expedient of paying off their debt at a considerable saving to the company, and, at the same time, with great benefit to the shareholders. For instance, they created 17,624 quarter shares, representing in capital only £440,600, and they say to the receivers of these, "Now, if you will take upon yourselves to pay the interest of the debt, and the debt itself, as it falls in, we will give you the full dividend upon these quarter shares, and, when you shall have paid off the debt, we shall save in capital near £100,000." As yet, only 2*l*. 10*s*., or £44,060, have been called up, and these quarter shareholders stand in this position:—they are receiving at the rate of 3*l*. per annum on the 2*l*. 10*s*. paid up, out of which they have to pay 1*l*. 2*s*. 6*d*. per annum, for interest, leaving 1*l*. 7*s*. 6*d*. net for their clear dividend on their 2*l*. 10*s*. share, or about 54 per cent. But, as a set off, they have still to pay about 27*l*. 8*s*. 6*d*. on each of these quarter shares, besides the already paid sum of 2*l*. 10*s*.; that is, the quarter shares will cost somewhere about 30*l*. each.

In the same way, the London and Birmingham Company are paying the full dividend on their quarter shares, on which only 5*l*. has been paid. I have never, however, heard with what prospective advantage to the company this was done. The Grand Junction plan is a good contrivance eventually for saving capital to the company, though at present at the expense of the other shares; but the London and Birmingham plan appears to me to be now damaging the original holders, and with no prospective benefit.

Supposing D to be the per cent. amount of debt on the capital actually paid, or the per cent. interest on it, i the per cent. interest on the capital and debts together which the profits would pay, and s the per cent. dividend on the shares or capital alone after paying the interest, we have the following simple equation from which to deduce any one from the rest, namely:—

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$$100\,s + \mathrm{D\,d} = (100 + \mathrm{D})\,i.$$

$$\text{Whence } s = i + \frac{i - \mathrm{d}}{100}\mathrm{D} \text{ and } i = \frac{100\,s + \mathrm{D\,d}}{100 + \mathrm{D}}$$

By the second equation it appears that if the debt was about one-fourth of the paid-up capital, and the interest of the debt was 5 per cent., and the concern paid 11¾ per cent., the shareholders ought to divide nearly 13½ per cent. This, as we shall presently see, is the case with the Grand Junction, considering their loan as a debt; but they have only divided 12, in consequence, chiefly, of the heavy sum they have laid by for depreciation and a reserved fund, and the operation of the quarter shares.

If we were to go closer into details, they ought to have a better dividend than we have given them, because we have not taken in the whole of their half-year's income, nor £9000 balance on the preceding account, while we have comprehended every item of their expenditure for the half-year, and have only reckoned the debt 25 per cent., whereas it exceeds 27.

If the debt was two-thirds of the paid-up capital and interest together, and the profits would return 10 per cent. on the whole debt and capital, the shares, with 5 per cent. interest on the loans, might divide near 13⅓ per cent. on the paid-up capital. This is nearly the position of the London and Birmingham Company. Owing, however, to the large sum set apart for depreciation and the quarter shares, on which, as I have said, only *5l.* capital is paid up, receiving the full dividend as if *25l.* had been paid, the old shares only receive 9½*l.* per share, or about 10½ per cent. Such is the unfortunate operation of these preference shares and the depreciation fund. It is true we have reckoned the debt larger, and, therefore, more advantageous than it is to the shareholders, and have taken the interest divisible upon the total cost greater than it really is; but after making due allowances for all this, the dividend on the shares would cover 13 per cent., if it was not for the operation of the preference shares and the depreciation fund.

With the South Western they only pay 5 per cent. interest on the Gosport branch, that is, on an additional £296,500, which reduces their paid-up capital to £1,529,000, and increases their debts to £926,600, or to above 60 per cent. of it. On the total of capital and loan, we shall find presently that this company can pay 6¾ per cent. Therefore, allowing 5 per cent. upon the debt, which is ⅗ths of the paid-up capital, and we shall have 7.80 for the dividend per cent., which might be made on the shares. The amount divided is near 7¾ per cent., very nearly the full one, and they hold a balance of £8750 in hand.

The Great Western would pay 5.8 per cent. on the loans and capital, and has 110.7 per cent. of paid capital in loans. Therefore, if 5 per cent. be paid on these, the dividend ought to be 6.7 per cent. on the shares. At the last meeting, a dividend of 6 per cent. was declared.

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The length of line run by the London and Birmingham, including the Aylesbury branch, is 119½ miles; of the Grand Junction, including the Liverpool and Manchester, and Chester and Crewe, it is about 133½; of the South Western, taking in the Gosport branch, 92¾; and of the Great Western, including the Bristol and Exeter, and Cheltenham Union, 169 miles. Hence, taking the receipts earned during the past half-year, exclusive of other sources of revenue, and the expenditures, we have—

	Length work'd miles.	Half-year's		Half-year's		Per centage of expen. on receipts.	P.ct. on cap. and loans for ½ year of		½ yr's profit per cent. on		Cost per mile.
		Receipts.	Expend.	Receipts per mile.	Expend. per mile.		Receipts	Expen.	Capital and loans.	Paid up cap. alone	
		£	£	£	£	£	£	£	£	£	£
L.&B.	119½	429023	134684	3590.2	1132.3	31·685	7·2782	2·3061	4.9721	6.53	52396
Gr. J.	133½	238207	104988	1784.2	784.6	43.973	10.5220	4·6375	5.8845	6.80	21525*
S. W.	92¾	153162	70284	1651.3	757.8	45.889	6.2372	2·8622	3.3750	3.91	26475
G. W.	169	337008	152787	1994.2	904.1	45.336	5.3145	2·4094	2.9051	3.35	53968

* This is given by Mr. Moss, the Chairman. The other costs per mile are computed upon the number of miles constructed.

This table affords us some very instructive information.

Many persons, for example, imagine that the amount of traffic per mile per week, as given in the Railway Magazine at the request of some high authorities, is indicative of the value of the line. Taking an extreme case, this would be true, for if a line had no traffic at all, it evidently could be of no value. But the gross amount of traffic, or the amount per mile, goes a very little way towards deciding the merits of a line. For instance, we have here the London and Birmingham at the head of all the railways in receipts, and more than double of another railway, the Grand Junction, which divides upon its whole cost, and with the dead weight of the Chester and Crewe hanging upon it, near 2 per cent. more. Receipts, therefore, are poor criteria of the merits of a line. They are good tests of the quantity of business done, and of the foundation on which profits may be made, but go no further.

Others, again, think the expense per mile a proof of the economy or extravagance of a company in the management of their affairs. This is a position equally as absurd as the preceding. The London and Birmingham is, upon this principle, nearly twice as extravagant as the South Western, and yet it would pay, upon the whole cost, near 3 per cent. per annum more dividend. Again, the Grand Junction is, if expenses per mile are a test, less economical than the South Western; nevertheless, it pays a good way towards double the dividend. A little reflection would tell us that the mileage expenses are influenced more by the amount of business done, than by the economy

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of management. But there are some, and even public writers, who have such crude notions upon railways, as to make high mileage expenses a ground of complaint against companies.

Equally absurd is another point on which much stress has been laid. I allude to the expenses per cent. of the traffic upon the receipts. Many persons exclaim, if one company transacts their business at a higher per centage than others, that things are worse managed there than where the per centage expense is much less. Referring to our table again, and we shall perceive the unsoundness of this doctrine. The Grand Junction is near 40 per cent., on the per centage expenses, more expensive than the London and Birmingham, and nevertheless can divide upon its whole cost at the rate of 11¾ per cent., while the London and Birmingham cannot divide 10. Again, the South Western is apparently paying a higher per centage expense on its receipts than the Great Western, and the receipts per mile are much less; and yet it pays at the rate of 6¾ per cent. on its cost, while the Great Western cannot pay at the rate of 6 on its cost, though it has divided, and apparently justifiably, at the rate of 6 on the paid-up capital.

The fact is, the per centage expenses depend upon two things, the fares and the amount of business. Other things alike, if the fares are higher, the per centage expenses will be less, and *vice versa.* Again, the more business, the less in proportion is the expense at which it can be done, simply because the standing expenses will bear a less proportion to the receipts, when great, than they will when little. For my part, I would rather see, where there is a scope for business, the per cent. expenses high, for the probability is there would be much more trade and profit.

The fact is, receipts or expenses per mile, or per centage expenses on receipts, are all fallacious foundations upon which, separately, to ground an opinion in favor of any line. *Railways are strictly commercial enterprises, and it is the annual per centage of profit alone on the capital, as in any other undertaking, that determines its value.* The smaller, therefore, this capital is, the more likely the line is to pay, and hence every effort should be made, in the construction of the line, to keep the cost down. Had the London and Birmingham, with its immense trade, (nearly double that of either of the other lines,) been made at anything like its original estimate, or like the cost of either the Grand Junction or South Western, it would, with its economy of working, have paid a magnificent dividend. The same, no doubt, would be the case with the Great Western, when it comes into its full receipts, which will not probably be for these two or three years. Never was economy of construction more forcibly exemplified than in the comparison of the London and Birmingham and the Grand Junction. With more than a double business, and an expenditure proportionably much less, the Grand Junction leaves the London and Birmingham far in the rear of profitable undertakings, for no other reason than that the total mileage cost of construction of the one has been about 143 per cent. more than that of the other. But the Grand Junction, nearly the lowest of the four in the amount

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of its business, having been constructed the cheapest, stands at the head of them all as a commercial speculation. Railway Mag.

Observations upon the Comparative Advantages and Inconveniences of the Employment of Iron Wire, or Bar Iron, in the Construction of Suspension Bridges of great span. By M. Le Blanc, *Chief Engineer of Bridges and Roads.*

Cables of iron wire, and chains composed of bars of wrought iron, may be compared with reference to their economy and their durability. As regards economy, the question scarcely deserves discussion, and it is easy to prove *à priori* that, in all possible cases, iron wire has the advantage over wrought iron. In fact, the Council of the Ponts et Chaussèes has adopted the principle, that cables of iron wire should be submitted to a tension of 12 kilogrammes (26½ lbs.) per square millimetre (.0016 square inches) of section; but for bar iron it was decided that the *maximum* of tension shall not exceed 8 kilogrammes (17.6 lbs. nearly). This principle is founded upon the comparative resistance of iron wire, No. 18, ordinarily employed in the construction of cables, and of iron bars 3 to 6 centimetres (1.2 to 2.4 inches) in diameter.

The natural consequence of this principle is, that the section of a chain should be greater by one-half than that of a cable, for the same tension; this involves a proportional increase of its weight. In cables of iron wire no joints are used, or, at most, but a single one, as in the bridge of Argentat; and this joint, made up of two small eyes, weighs but little—on the contrary, they are numerous in chains, and, where the system is rather complicated, as I shall prove it should be in bridges of great span, each one of these joints weighs at least 140 kilogrammes, (309 lbs.) On the supposition that the suspension rods are 1.2 metre apart, (47¼ inches,) as there is a joint for each rod, there will be 233 kilogrammes (514 lbs. nearly) for a bridge of 180 metres (590 feet) span. This additional weight, together with that of the bars themselves, which, as we have just seen, is one-half greater than that of the cables, produces an excess of tension which must again be resisted, whence there arises a new increase of section, and, consequently, of weight, in the chains. In applying these principles to individual cases, it is found that the weight of the unit of length of a system of chains exceeds double that of a system of cables.[1] Now, as the price of iron wire is once and a half that of bar iron, it is plain that the use of iron wire is more economical than that of wrought-iron.

I have proved that the total tension is much greater when chains are used; it follows that greater strength must be given to the moorings, and to the intermediate piers, when the bridges have several openings, or bays—a new cause of increase of expense.[2] It appears

1 In the comparative proposals which I presented for the bridge of Roche Bernard, I showed that these weights are in the proportion of 11 to 25; in order to replace 11 kilogrammes (24 lbs.) of iron wire, which, at 1f. 50c., cost 16f. 50c., we must employ 25 kilogrammes (55 lbs.) of wrought iron with 25 francs.

2 In bridges of several bays, the cables, or chains, should be fixed to the intermediate

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to us to have been thus thoroughly proved, that, in regard to economy, the cables of iron wire are superior to chains of wrought-iron. Let us now compare the two systems in relation to their durability. The principal objections which have been made to the employment of iron wires are the following:

1st. They offer greater chances for rapid oxidation.

2d. The imperfection of the present process for manufacturing the cables, does not allow us to give an equal tension to all the wires, so that, when the cables are raised to their places, the wires which are under most tension have to support many pounds in excess—while those under least tension do not draw at all.

3d. Cables form a system less rigid than chains of wrought-iron do, so that the horizontal oscillations of the roadway are more considerable in the former than in the latter case.

I believe that I have not withheld any of the objections urged against the employment of iron wire, nor weakened those I have presented. I shall now examine them in order.

First objection.—They offer a much greater chance for oxidation.

It is certain that if we expose to alternation of dryness and humidity a bar of iron and a certain number of isolated wires, the sum total of their individual sections being equal to that of the bar, the surface attacked will be far greater in the wires, and in them the oxidation will be most rapid.

In confining ourselves to this general fact, without reference to any of the means employed by art for retarding this oxidation, it will be well to examine if even this inconvenience of the more rapid destruction of the cables is not more than counterbalanced by the advantages which they present. It is very evident that if the cables remain only forty years without being renewed, while the chains may last for sixty or one hundred years, we must calculate what will be the amount, at the end of forty years, of the sum saved by the use of iron wire instead of bar iron.

To render this more plain, I will give an example. I suppose that a given suspension bridge requires 200,000 kilogrammes (441,096 lbs.) of iron, (which was nearly the quantity for the bridge of Roche Bernard.)

The expense of the system of suspensions,	300,000 francs.
According to note, (1,) to replace the iron wire, there must be used 454,545 kilogrammes of wrought-iron, which would cost	454,545 "
Saving in favor of iron wire,	154,545 francs.

piers, in order to avoid the great changes of form which result from unequal loads upon the two bays, if the chains and cables can slide freely over the top of the piers, because those piers have to resist only the difference of the tractions produced by different additional loads upon the two bays, it would appear, at first sight, a matter of indifference whether the permanent loads which are in equilibrio are greater or less; nevertheless, it is plain that, the less these permanent loads are, the better the piers are in condition to resist the *maximum* load of one bay, the other being destroyed—it is, then, not unimportant that we diminish the permanent load as much as possible.

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Now, this sum, put at interest, will amount, at the end of twenty-three years, to 475,506 francs; and, supposing that the cables must be entirely renewed at this time, there will still remain a surplus of 175,596 francs, which will be more than sufficient to produce, at the end of another twenty-three years, a new capital equal to the cost of the system of suspension. In the case which we have considered, cables of iron wire, lasting but twenty-three years, will then be preferable to chains of indefinite duration. The supposition that isolated wires will last twenty-three years without the necessity of being renewed, is not without foundation, and we shall produce a fact which strongly tends to confirm it.

M. Montgolfier, Jr., having learned that a grating of iron wire from the church of St. Martin's, at Paris, was about being taken down, after having remained forty years without any repair, had the curiosity to prove these wires, after having carefully ascertained their number, and he was convinced that they had lost but one-fifth of their entire strength.* This loss of strength is not sufficient to require a complete renewal of the system of cables. But the most determined opponents of the use of iron wire confess that cables do not afford such facilities for oxidation as detached wires. The greasy substance which covers them affords a powerful preventive to rust—their union preserves them in the interior, more or less, from moist air—the ligatures are a still further obstacle to its introduction—and, finally, the careful superintendence which should be given, are all reasonable motives for hoping that the effects of oxidation may be diminished in a remarkable manner.

It may be objected that experience has not fully confirmed the opinion, however probable it may be, that cables are less susceptible of the attacks of oxidation than iron wires. I confess that no one fact can, as yet, incontestibly, prove the justice of this opinion; but there are several which we can produce, capable of giving much strength to it.

The bridge of Tournon has been in existence eleven years, but no very considerable trace of oxidation has manifested itself, at least to my observation, upon the surface of the cables; and, if there existed any in the interior, it would not have failed to show itself by a brownish stain upon the outside of the paint which covers them.

A bridge of iron wire was built at Brest in 1526; the cables, exposed to the salt air, which attacks iron with so much energy, should have undergone a remarkable deterioration in the space of three years. M. Trotte de la Roche, Chief Engineer, who, on account of the plans adopted for the port, was obliged to dismount it, took the pains, at the invitation of M. Inspector General Lamblardie, to prepare a *proces verbal* of the state in which he found the cables.

It appears from the *proces verbal*, 1st. That the continuous ligature which covered the cables was slightly attacked, but that by the first scratch of the file the oxidized portion was removed. 2d. That the

* The increase of oxidation is not as rapid as would be supposed from the first observations made—for the first layer of rust which covers the surface of a bar of iron, instead of favoring this oxidation, proves a coating which is an obstacle to it.

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exterior wires of the cables showed slight traces of oxidation, but that the slightest scratch of the file caused them to disappear. (M. Trotte de la Roche supposes that the oxide was only deposited upon the wires of the cables, and that it came from the ligatures.) 3d. That the interior wires were perfectly untouched. Eight years is a short space of time, but if we consider that the effects of oxidation probably continue to decrease, we may conclude that they are not so very rapid, but that the fears entertained upon this point are greatly exaggerated. An observation has been made which is worthy of remark; it is, that, in chains, the surface of the bars, which is attacked by oxidation, proves the portion of them offering the most resistance, while, in a cable, the interior portions have the same strength with the others.

Second objection.—The imperfection of the present process for manufacturing the cables, does not allow of an equal tension in all of the wires, so that, when the cable is raised to its place, the wires under most tension are overstrained by many pounds, while those under the least tension do not draw at all.

This last objection is a serious one, and cannot be absolutely done away with—that is to say, it is impossible to prove that this defect does not deserve the most serious attention; but we can employ, in defence of iron wire, negative arguments, or, in other words, we can prove that it is not possible to resolve the problem of equal tension in a more perfect manner by the system of chains than by that of cables of iron wire. We must, in the first place, distinguish carefully between bridges of large or small span; in the latter, where the tension requires only a section of the chains equal to that of 4 to 8 bars of about 0.05 metres to 0.06 metres (2 to 2⅛ in.) in diameter,* (dimensions beyond which the quality of the iron becomes considerably deteriorated,) we can establish, on each side of the bridge, two or four separate chains, in one or two layers, each chain being made of a single bar only; in these two cases the problem of equal tension is perfectly resolved, and although, in the second, each suspension rod bears upon two chains which cannot have exactly the same curvature, the holding plate of the rods will always bear upon the two chains, which will then support equally their share of the whole weight of the bridge. By establishing three, or even four, layers,† we can form an excellent system of sixteen chains, each made of a single bar; but these sixteen chains present only a total section of less than 44,000 millimetres, (97,041 lbs.) corresponding to a tension of 352,000 kilogrammes, (776,329 lbs.)—that is to say, to bridges of medium span; but if we pass to bridges of such a span that the tension increases to more than a million of kilogrammes, it will be necessary that the chains should be composed of 48, or even 64, bars—that is, 24, or even 32, bars on each side.

Let us consider the last hypothesis, which applies to the case of the

* I reason on the supposition of the use of round iron, of which I need not prove the superiority over square iron, that is hammered again after being reheated to a cherry red.

† I suppose it would not be desirable to employ more than four layers—this number is already considerable and troublesome in the passage over the towers, and in the moorings.

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bridge of Roche Bernard. It is impossible to employ the simple system of suspension rods resting upon a couple of chains, of single bars, and arranged in layers, for we would then have sixteen of these layers, one above the other, which, beside the inconvenience presented by a considerable height, would allow of the attachment of suspension rods only at every sixteen intervals upon the same chain. Here, then, it is necessary to employ a more complicated system, viz., to form the chains of several bars, fastened together by a single bolt; in this case, I would reduce the number of chains to eight, and form them of eight bars, fastened by one bolt. We can double the number of chains, and so reduce to four the bars in each, by making each rod rest, by means of plates, upon two chains at once; but if the two chains forming the couple are not in the same plane, the upper plate of the rods will bear only upon one of the chains—for it must remain parallel to the plane of the four bars—and one-half of the system will support nothing; this disposition is too faulty to be adopted—this is my opinion in the hypothesis of eight bars to each chain, and fastened by one bolt.

Whatever may be the manner of forming the eye at the end of the bar, either by welding it to the end itself, or by bending over a portion of the bar, it appears to me very difficult to prevent differences in length of at least a millimetre between the bars. Now, if there is this difference between bars, 5 metres (16.4 feet) in length, the shortest must lengthen a millimetre, or .0002 of their length, before the others draw. But we know that a tension of two kilogrammes per square millimetre of section produces, upon a bar, an elongation of .0002 of its length. The bars, then, of which we are now speaking, are strained to the amount of 4 kilogrammes (9 lbs.) per square millimetre, before those beside them suffer any tension; what will this amount to if the differences in length are more than one millimetre?

We see, then, that the problem of equal tension is as difficult of resolution for a complicated system of chains as for iron cables; for, supposing that, in the two systems, the excess of tension, either of one wire over another, or of one bar over another, is the same, this excess will be a much smaller fraction of the absolute strength of wire than of bar iron; moreover, the manufacture of cables affords a greater hope of perfection than that of chains.* We see, now, that the second objection has no more weight than the first, to decide us in favor of wrought iron chains.

On the other hand, there are objections against the employment of bar iron more difficult to remove, and which will give additional strength to the reasons which have induced me to yield the preference to iron cables. These objections are as follow:

1st. The greater part of chain bridges which have fallen have given way at the bolts which unite the links. Now, it is extremely difficult

* To make the bars as equal as possible, we can, indeed, after having bent and welded the ends, drill through all of them which make up a link of the chain, when cold; but it is evident in this case, that, to prevent the drilling from diminishing the strength of the eye, we must either give greater size to the bar in this part, or flatten it, involving a heating which injures the quality of the iron.

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to calculate the strength which should be given to them, as we do not perfectly understand the manner in which they resist the strain; if we compare them to bars placed upon fixed bearing points, and charged with a weight in the middle, and the resistance of which is derived from a formula $P = M\frac{a b^2}{2 c}$, we find the dimensions very small—too small, indeed, according to many experiments. If we suppose them to resist, as if drawn in the direction of their length, (and many constructors admit this hypothesis,) we arrive at large sections, which greatly increase the weight of the joint; besides this, we have no certain information as to the quality of the iron which they need; it should not be so soft as that of the chains, because no curvature is required, but still it should not be brittle. To avoid mistakes prejudicial to the durability of the work, it is wise to make them rather too strong than too weak; but, as I have just said, an increase of weight is the consequence of this precaution.

2d. The making of the eye requires great attention; it has been observed, that, when the bolt is too little, during the proof, a rent takes place from the outside to the inside of the head of the eye; when the bolt is too large, the rent opens from the inside toward the outside. Now, as it is almost impossible that the work of man should be perfect, in order to avoid the inconvenience abovementioned, several constructors have proposed to swell out the head of the eye, in order to give it greater strength; but, to do this, we must re-disturb the particles of iron, by hammering after having heated it—an operation which I have already designated as faulty.

3d. During the oscillatory motions, which take place in all suspension bridges, the irons rub forcibly against each other at all the joints, and this tends to wear them in those parts which have the greatest strain. This inconvenience does not exist in wire cables.

4th. In the moorings we are compelled to use curved irons, which have, of course, been re-heated,* and are most often squared; this new heating, and the difficulty of proving them, obliges us to give a greater size, which involves another increase of expense.

5th. In very cold weather, iron becomes brittle; wire, enveloped in grease, and not in immediate contact with the air, must be less brittle than naked bars of iron.

6th. Cables, in bridges of great span, can be much more easily raised to their places than chains. In the proposal for the bridge of Roche Bernard, I have calculated that the weight of a cable would be 7968 kilogrammes, (17,673 lbs.,) while each chain would weigh 31,496, (69,462 lbs.) A work equally difficult, it may be said, has been executed at the Menai bridge; but if this proves that it is not impossible, it does not prove that it is not very difficult.

* There are, for instance, some red shear (hot short) irons which lose nothing by being wrought at a white heat, but which are injured in quality when wrought at a less elevated temperature. But the workmen cannot confine themselves to fulfil those conditions exactly, whence it happens, in irons which have even been proved, that the reforged portions become bad, and, consequently, that only the final proof can give evidence of this imperfection; but, as we have just said, it is very difficult to prove curved bars.

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M. Vicat has asserted that wires, before breaking, suffer a considerable elongation, which announces the rupture beforehand, and thus gives time to make the necessary repairs, while chains break instantaneously. This advantage of iron wire has been disputed, in the case of wires united in bundles by ligatures, and the interstices of which are filled by grease. M. Frinot thinks that these bundles form a brittle system; he, doubtless, would like to say, as brittle as bar iron. In support of his opinion he has cited the "herse," a sort of skein of hempen thread, which has most strength when its elements are free, and loses part of it as soon as the loose threads are bound together, and approximated to the condition of ropes. If this assertion is confirmed by experiments—and I have prepared some for this purpose—cables will, in this point of view, be neither worse nor better than bar iron.

Third objection.—Cables form a less rigid system than bars of wrought iron, so that the horizontal vibrations of the roadway are much greater in the former than in the latter. For equal curves and weights, this is true; but when we have once given the preference, even in point of durability, to wire over bar iron, (and I confess I have done so,) will we not gain more by increasing the rigidity, by means of the greater weight of heavier timbers for the roadway, and by diminishing the curvature of the cables, or the tension which they should bear per square millimetre of section, than by substituting chains for cables? These latter likewise admit of an arrangement which cannot be adopted for chains. I refer to the cradle form; and, in this case, the outside cables being in a plane, inclined from the vertical, have a tendency to draw the whole roadway towards them, and, as this takes place on both sides, it follows that the roadway is kept in its position better than it would be by means of stays.

I offer these reflections to the readers of the Annales, as the result of perfect conviction in my own mind, after deliberate consideration; and I can indulge the hope that this conviction will be shared by at least a small number of my associates. I shall examine, in a subsequent article, the advantages and inconveniences of a diminution of curvature, and the defects in the proof which chains and cables undergo, either before or after being placed.—*Annales des Mines.*

Mining Journal.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Explosion of the Boiler of the Steamboat Medora.

To the Committee on Publications.

Gentlemen—In my memoir of the explosion of the steamboat "Medora," published in the November number of the Journal, for 1842, I state (pages 320–21) that "another witness says, that, when the weights were pushed out by him on the long lever as far as they would go, the steam pressure was twenty-two inches by the gauge, having shown twenty inches just before, and that, by order of the

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acting engine-man, he then put an *additional* weight, (how much he does not say,) and that, two or three minutes afterwards, the boiler blew up." The witness here referred to was Mr. Joseph Cragg, who, though not mentioned by name in my memoir, has been so connected, by the newspaper accounts of the accident, with the treatment of the safety valve just before the explosion, that, in the belief that he would be recognized by the readers of the Journal, and be visited with their censure, he has recently called upon me to request that I would cause his explanatory statement, which follows, to appear in the Journal, as an appendix to the history of the occurrence it contains. I comply cheerfully with Mr. Cragg's request, which indicates a proper anxiety to free himself from the imputation of a want of due regard for his own life and those of others. I also add the statements of Messrs. Ramsay and Collins, who accompanied Mr. Cragg in his interview with me, and who were with him in the Medora when she blew up. I had seen none of these individuals at the time of preparing my memoir, and I have, since submitting it, regretted that my leisure did not allow me to make more extensive inquiries, into the circumstances of the explosion, among its surviving eye-witnesses. Many of these (and among them the three just mentioned) were indeed, at the time of my examination of the matter, not in a condition to be seen and questioned respecting it; and I was therefore compelled to rely principally upon the evidence of those who, being more distant from the immediate scene of the explosion, escaped injury from it, but who, on that very account, were less correctly informed of its attendant circumstances. The official inquisition into the affair, though promptly instituted, and commendably attended to by the Mayor in person, led, as usual in such investigations in this country, to no determinate results. We could learn useful lessons from the old world in the conduct of these inquiries, which should always be of the most searching kind, and be prosecuted with the utmost rigor by the local tribunals, which ought to be vested with all the powers necessary to that object.

Mr. Cragg says that, shortly before the explosion, he was standing near the boiler, and, observing the steam *weeping* out of the safety valve, he mentioned the fact to Duncan Ferguson, the engineer, who requested him to push the weight out upon the lever. He (Cragg) accordingly took down, and set upon the deck, a door in the house surrounding the boiler, which door was immediately opposite the lever, and, when removed, gave access to it, and exposed it fully to view. Mr. Collins, who was standing by, held the door upright on the deck, while Cragg pushed out the *smaller* weight, (described in my memoir as weighing 56 lbs.) as far as it would go; that is, close

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up against the larger weight of 200 lbs., already out at the extremity of the lever. The smaller weight laid, and was fitted upon, the lever by an open slot, or groove, in the bottom of the weight, which allowed it to slide to and fro. The opening in the larger weight which received the lever was, on the other hand, a longitudinal perforation through the centre of the weight, so that it could not (as could the smaller one) be dropped down upon the lever, but was pushed upon it from the end. The reason of this difference in the manner of supporting the two weights upon the lever, will be explained by Mr. Ramsay's testimony. Now, Mr. Cragg declares that the *additional weight* spoken of in my memoir was *this very smaller weight of* 56 *lbs., and that no other than the two weights therein described were put upon the lever; nor any other means, whatever, of holding it down, employed.* He further says, that as, *before* he pushed out the smaller weight, the steam was just beginning to escape from the safety valve, which was *dancing* on its seat; so, *after* that weight was slid out against the large one, the valve closed, so as to allow only two small puffs of steam to escape from them, up to the moment of the explosion. That after he had pushed out the weight, he went round to the gauge-cocks, and tried the two uppermost of the four, from the highest of which steam and water, and from the next lower water alone, issued. That he returned towards the safety valves, and was wiping his hands of the color he had got upon them from the newly painted door abovementioned, when the boiler exploded, and blew him out of the side of the boat, into the water. He barely escaped drowning; his face and leg were badly scalded; five of his ribs were broken; his sight was lost for a time, and he was confined for several weeks to his bed. He moreover says that the gauge stick, which a witness (one *Smith*, see p. 320,) states that he saw run up to the upper deck just before the explosion, *could not have been seen to do so,* on account of a board partition near to the gauge, *behind* which the stick would have passed up, so as to conceal it from view, for a space of some eighteen inches, before it could have reached the deck.

Mr. Cragg also states, that Mr. Watchman told him, some time after the accident, that, in speaking before the coroner's inquest of *extra weight* put upon the lever, he *meant* the 56 lbs., which has been spoken of all along as the smaller one of the weights *belonging to the valve,* and that he had no intention to find fault with what had been done by Mr. Cragg. The newspaper report of Mr. Watchman's examination before that inquest, leads, however, to a very different inference on the part of the reader of the report, who cannot help seeing that Mr. W., therein, intimated very plainly his belief that the extra weight of which he spoke had nothing, by right, to do with the valve,

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but was specially provided for the occasion by those whom he supposed to have tampered with it.

Mr. Albert G. Ramsay, now the engineer of the steamboat Jewess, and who was to have been engineer of the Medora, stated to me that he was standing on the upper deck, close to the cylinder, when the boiler burst, and that, in attempting to get out of the way, he fell down into the hold, and nearly lost his life. He says that, in the two trials of the Medora previous to the day of the accident, the steam gauge was not in a situation to show the pressure correctly, because the *stick* was four or five inches too long, and because there was a considerable quantity of water, from condensed steam, in the vent tube, which water *floated* the stick; and also because the gauge board, with its accurate divisions, was not then up, but the inches merely marked with chalk on the bulkhead, from rough measurements, which he made himself; and that these measurements did not go above 24 inches, leaving all above that limit to be guessed at; so that he thinks the gauge, on those previous trials, showed perhaps nine or ten inches too much pressure. This, he thinks, may account for Mr. Watchman's having supposed (see memoir, p. 319,) that the boiler, on those occasions, had been proved to 27 and 31 inches of steam; while, in fact, the proof was perhaps to not more than 18 or 22 inches. That on the day of the explosion, however, an accurately marked scale had been put up, the stick reduced to its proper length, and the water removed from the mercury; so that the true pressure was shown on that occasion. Mr. Ramsay now further says, that, in the two preliminary trials of the boiler, the *only weight upon the lever was the large one*, of 200 lbs., which, of itself, could not have produced a steam pressure of more than 18 or 19 inches; and that the smaller weight of 56 lbs. was then cast and put upon the lever in the manner above described, to assist the deficient action of the large one, and that it was, on this account, considered and called an *extra weight.* He also says, that the space within which the small weight could be pushed backwards and forwards, when the large one was at the end of the lever, did not exceed nine inches, owing to an upright iron guide, which embraced and steadied the lever, at a distance of thirty-one inches back from its extremity. He states, furthermore, that the end of the lever came close up to, or rather *just through*, the boarding of the boiler-house; so that there was no room upon it to hang weights outside of the large one, and any such weights must have been seen, had they been so suspended.

Mr. Collins confirms Mr. Cragg's statement of the circumstances under which he pushed out the small weight upon the lever; and he (Collins) also affirms positively, that no other weights than the two

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abovementioned were put upon the lever, which he had in full view through the open door of the boiler-house, up to almost the moment of the explosion, by which he was blown into the water, scalded, and otherwise injured.

Such is the testimony of the three individuals above named, which I respectfully ask may be published in the Journal, at their request, and *upon their accountability for its truth.* If its truth be admitted, it would appear that the steam pressure did not, in fact, rise above the amount ($23\frac{6}{10}$ lbs. per square inch) estimated in my memoir, and that the boiler gave way under that strain, although its strength was therein estimated to be $69\frac{44}{100}$ lbs. per square inch, or three times as great. We would then have to suppose the data on which the strength was computed to have been erroneous; that is, the iron must have been much weaker, or the workmanship less perfect, or the quantity of metal resisting the strain much smaller, than has been assumed in that computation. One or all of these possible errors in the elements of my calculations, may exist; but as I neglected no means of information available to me, I cannot blame myself if they are incorrect. The evidence is conflicting and unsatisfactory, and leaves the causes of the catastrophe involved in considerable uncertainty.

It appears that the three holes, *b, b, b,* shown in the back view of the boiler, were not *blown,* but *torn out,* having been the points of insertion of pumps, which were fastened down to the kelsons of the boat, and remained so attached when the boiler rose. This circumstance will assist in accounting for its rotation, previous to its fall.

I am, most respectfully, your ob't serv't,

Benj. H. Latrobe, C. E.

Baltimore, Jan. 25, 1843.

Franklin Institute.

Report on the Carcel, or Mechanical, Lamp.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination, by Mr. Alfred Bennett, the Carcel, or Mechanical Lamp, REPORT:

That the lamp is that long known in France as the Carcel Lamp, from the name of its inventor, and for several years in use in this city under the names, Diacon Lamp, and Mechanical Lamp.

In these lamps, the oil is raised to the wick by machinery contained within the ball, or stand. As no novelty is claimed by Mr. Bennett, the committee do not propose to describe this machinery, but proceed at once to the comparison of the light and expense of these lamps, with those of other lights in common use.

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The comparison was made by means of a photometer, similar to that used by a former committee when examining Mr. Greenough's lamp and chemical oil. It consists essentially of two plane mirrors, enclosed in a box open at each end, placed back to back, inclined at an angle of 45° to the horizon, and forming a right angle with each other. The lights to be examined are arranged at a convenient distance apart, and the photometer placed between them, so that the light from each shall fall fairly upon one of the inclined mirrors, and, thus diverted into a perpendicular direction, it is received upon a piece of white paper, of even texture, which closes an opening in the top of the box, where their respective intensities can be conveniently compared. The instrument is moved in the line of the lights until the intensities are equalized, when the distances from the centre of the photometer to the centres of the lights are measured, and the light estimated as proportional to the square of the distance.

Four lamps were submitted to the committee for examination by Mr. Bennett, which were numbered, for convenient reference, according to the diameter of the wicks, No. 1 being the largest.* The standard used was the gas argand burner in the committee room, which was ascertained to burn 4.25 cubic feet of gas per hour, the expense of which, at the present price of gas, is 1.4875 cents per hour. As the experiments were not made with the purpose of deciding upon the economical value of gas, the committee think it but fair to observe that no attempt was made to determine whether more economical gas-burners were not in use, or might not be devised.

Mr. Cornelius kindly furnished to the committee, for their experiments, two solar lamps, (Nos. 1 and 2,) and an argand lamp, fitted with a cap to direct the outer current of air upon the flame, (which lamp is called in the table a semi-solar lamp.) In reference to which it is to be observed, that the solar lamp No. 2 was of a pattern which has been for some time abandoned by the makers, as affording a less economical result than that given by the new form.

The committee have also incorporated into their report the last series of comparative experiments made by them with the camphine lamps of Carr, Dyott, and Gould; and the result of experiments to determine the comparative values of sperm and lard oil, when burned in the Carcel lamp.

The Carcel lamps, Nos. 1 and 3, were burned with fall strained oil, at 90 cents per gall.; Nos. 2 and 4 with winter strained oil, at $1 00 per gall.

The solar lamp, No. 2, and the semi-solar, with winter strained; No. 1, with fall strained oil.

The following table gives the result of these experiments; the economical value being estimated as the intensity divided by the expense, or the relative quantity of light for the same expense.

* These lamps are numbered by Mr. Bennett as follows:

No. 1	of the Committee	is No. 15	of Mr. Bennett.
" 2	"	" 13	"
" 3	"	" 12	"
" 4	"	" 10	"

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Table, showing the relative intensities, the quantity consumed, the duration of experiment, the cost of material, the expense per hour, and the economical value of different lights.

Note.—The economical value is estimated as the quantity of light at the same expense; that is, as the intensity divided by the expense.

		Intensity.	Quantity consumed in pints.	Duration of experiment in hours.	Cost of material per pint.	Time of consum'n of 1 pint in hours.	Expense per hour in cents.	Qu'n'y of light at same expense.
Gas,		1.					1.4875	1.
Carcel	No. 1	2.152	.92	5.8	11.25	6.32	1.78	1.8
	" 2	1.1	.766	7.	12.5	9.14	1.27	1.2
	" 3	.93	.766	7.	11.25	9.14	1.23	1.1*
	" 4	.69	.422	6.15	12.5	14.60	.86	1.2
Solar	" 1	2.13			11.25		1.85	1.71
	" 2	1.4	.481	4.05	12.5	8.42	1.48	1.4
Semisolar		1.152	.6	4.05	12.5	6.75	1.85	.93
Camp.	Carr	1.8	.25	2.50	7.8	10.	.78	3.4
	Dyott	1.69	.28	2.63	7.8	9.40	.83	3.
	Gould	1.75	.31	2.66	7.8	8.53	.91	2.86

The consumption and expense in this table were determined by an independent experiment. The solar lamp, No. 1, was introduced from after experiments.

The following experiments were instituted by the committee to determine the comparative values of sperm and lard oil, as burned in the Carcel lamp, which, from its construction, requires a better oil for its satisfactory exhibition than ordinary lamps.

The experiments were conducted in two similar Carcel lamps, and were continued, the first during eight, the second for nine, hours.

The lamp which was used in the first experiment for the sperm, was, in the second, used for the lard oil, and vice versa.

Experiment 1.—The oils used were lard oil, at 80 cents per gallon, and fall pressed sperm oil, at 90 cents per gallon. The experiment lasted eight hours, and the intensity was examined every half hour.

	11*h.* 40*m.*		5*h.* 05*m.*	5*h.* 30*m.*	6*h.*	6*h.*30*m.*	7*h.*	*Av'ge.*
Sperm oil	1.	no ch'nge until 5	1.	1.	1.	1.	1.	1.
Lard oil	.72	o'clock	.5	.46	.374	.41	.396	.63

Oil consumed, sperm 13.7502 oz.; lard oil, 12.5 oz.

* An after experiment with this lamp demonstrated to the satisfaction of the committee, that its less economical value was owing to its being used with too high a chimney. When tried with a better chimney, it gave the same result, as to economical value, with No. 2.

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Experiment 2.—The lamps were reversed; that is, after being emptied and carefully drained, the one which had been used with sperm oil was filled with lard oil, and vice versa.

	11*h.*	4*h.*	5*h.*	5*h.*30*m.*	6*h.*	6*h.*30*m.*	7*h.*	7*h.*30*m.*	8*h.*	*Av'ge*	*Av. of both*
Sperm oil	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Lard oil	.86	1.81	1.5	.83	1.	.86	.66	.52	.35	1.09	.86

Duration of the experiment, nine hours. Oil consumed, sperm 13.5 oz.; lard, 14.5 oz.

After the conclusion of the experiment, the lamp containing the sperm oil was compared with the gas standard, and gave the following comparative intensity—gas 1., Carcel 1.2; and as it was the lamp marked No. 2, in Table B, it demonstrates the admirable steadiness of these lamps, when burned during considerable periods of time.

The irregularity and diminution of light shown by the lard oil, and its consequent less economical value, was owing to the fact of the formation of a long and hard crust upon the wick, which finally reduced the light so far as to induce the committee to close the experiment. But farther experiments, with lamps of other constructions, would be necessary to enable us to decide upon the general question of the comparative values of lard and sperm oil, as burned in such.

In consequence of the representation made to the committee that the solar lamp heretofore used in their experiments, (marked No. 2, in Table B,) was not a fair average specimen of that kind of lamp, two new series of experiments were undertaken with a lamp selected by the makers, and in the presence of those interested in both lamps. The following were the results.

Experiment 1.—Oil furnished by the makers of the solar lamp.

	1*h.*	*h. m.* 1 30	2*h.*	*h. m.* 2 30	3*h.*	*h. m.* 3 30	4*h.*	*h. m.* 4 30	5*h.*	*h. m.* 5 30	6*h.*	*h. m.* 6 30	*Average.*
Carcel lamp,	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Solar lamp,	.85	1.	1.	1.	1.1	1.2	1.06	1.1	1.1	.85	.975	1.1	1.03

It was evident, from the irregular behaviour of the Carcel lamp, that the oil was not favorable to its use.

Experiment 2.—The same lamps were used, with oil furnished by the agent for the Carcel lamp.

	12*h.*	*h. m.* 12 30	1*h.*	*h. m.* 1 30	2*h*	*h. m.* 2 30	3*h.*	*h. m.* 3 30	4*h.*	*h. m.* 4 30	5*h.*	*h. m.* 5 30	6*h.*	*Av.*	*Av. of 2 exp'ts.*
Carcel,	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Solar,	.957	.87	.87	1.	1.	.99	.975	.975	.975	.975	.96	.96	.97	.95	.99

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In conclusion, without presuming to decide upon the relative merits of different lighting materials, the committee would make the following general remarks upon their evident advantages and disadvantages.

The gas possesses the advantage of giving a very bright and continuous light, not subject to variation when burned during a long period of time; in our city, at least, free from all obnoxious smell, or smoke, and requiring no trouble, care, or time, in its arrangement; and is cleanly. Its disadvantage is, that it is a fixed light, and can be used only at points previously determined upon.

The camphine possesses a remarkable intensity and high lighting power, with a brilliant white flame, and, from its cheapness, presents strong claims, on the score of economy, upon public notice. Its disadvantages are, the great inflammability of the material, the liability to annoyance from its disagreeable smell, and the injurious and unendurable smoke which proceeds from the lamp when out of order, or not properly regulated.

The Carcel lamps, although, from their construction, expensive, give an exceedingly steady, long enduring, and bright light, and are characterized by beauty of form, and total absence of shadow. They give, also, a highly economical result from the quantity of oil burned. In order to produce the best results, they, however, require the finer qualities of oil.

The solar lamp, although not so steady in its light as the Carcel, has a flame which, in the best specimens of this lamp, approaches very nearly, if it do not equal, that of the Carcel, in intensity. It is comparatively cheap, simple in its construction, not liable to get out of repair, and easily cleansed.

By order of the Committee,

Jan. 12*th*, 1843. WILLIAM HAMILTON, Actuary.

Practical & Theoretical Mechanics & Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Cool Sweating Process in Tanning.

It is a matter of much regret, that, at this moment, when every other art and manufacture has been benefitted by the discoveries of science, the manufacture of leather seems to stand, to a great extent, unimproved and unchanged by the progress made in chemistry, and uninfluenced by the rapid march of other branches of art towards perfection. Old modes of procedure have, in every other department of the producing interest, been discarded, and the entire processes revolutionized by the light thrown upon them from the discoveries in chemical and mechanical science. Though the investigating chemist has endeavored to improve the mode of manufacture, and much light has been shed upon that part of the process which he has examined,

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yet the tanner has done little or nothing to aid his investigations, being too generally content to follow the practices of his fathers, often erroneous, and founded upon false theory, or a mere hap-hazard method. It is true, that, in the mechanical processes, much improvement has been made upon the modes practised by our forefathers. We may trace them from early antiquity, when the flail served to break the rough bark for soaking in the pit, down through the stone crushing and breaking, by its revolution, the bark beneath it, to the adoption of the cast-iron mill propelled by steam, by water, or other powerful agent. The application of steam has been thought, by some, to aid materially in the extraction of the tannin; but that this is true, or that tanning with warm liquors, or with liquors containing tannin thus extracted, improves the quality of the leather, admits of a doubt. To these may be added various kinds and descriptions of reels, rolling machines, and other modes of lessening labor and expense, to describe all which, with the numerous attempted improvements, would require a volume. But it appears that these are all mere mechanical improvements, highly valuable, it is true, as far as they go, originating in the desire of the tanner to lessen those expenses which were more obvious to his understanding than the equally important losses which he was sustaining by erroneous processes in the chemical department of his operations.

That the manufacture of leather should have made such slow progress, is rather surprising when we consider the vast utility and extensive use of the article in every department of civilized life. The Hon. Gideon Lee, in his lectures on tanning, has truly remarked that, "In point of necessity, few manufactures surpass it. Leather, indeed, seems to enter into the uses of every other trade, every family, every person; nor does it stop at the useful—a large portion of ornamental furniture, equipage and dress, admit and require this commodity, in some of its numerous forms. Whichever way we look or move, we can not fail to see this indispensable article in use." Upon inquiry into the history of the progress of this art, we cannot find that any tolerably correct notion of the philosophy of tanning existed until within the last forty years. Prior to this, it was deemed a mere mechanical process, and the attention of chemists had never been turned to the investigation of the subject. That leather was a definite compound of the gelatine and albumen of the hide with the tanning principle, was unknown and unsuspected. It is true that some improvements have originated in a more definite knowledge of the action of the substances concerned. Of the tanning, properly so called, it is not our purpose at present to speak; but will confine our attention to that part of the process connected with the preparation of the hide for

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combining most advantageously with the tannin; we allude to the liming and bating, or the unhairing and cleansing, preparatory to introduction to the liquor, which is a solution of the tanning principle. The mode extensively used in England, upon the continent, and in the United States, is that of steeping the hides in a solution, or more properly a milk, of lime, in which they are allowed to remain from one to three or more weeks, according to the state of the weather and the texture of the hide, until they present the appearance which experience has taught is proof of the proper action of the lime. This has the effect to loosen the hair and epidermis of the skin, and render it easily removable by the after rubbing down, by means of a knife, upon a beam, or block. Another mode of producing the same result is that of suspending the hides in a close chamber, heated a little above the ordinary temperature of the atmosphere by a smouldering fire. In this case, the epidermis becomes loosened by incipient putrefaction. A so-called sweating process is in use in Germany, and by some applied in this country; but it, as well as the preceding, is attended with much risk—so much so as to preclude their extensive adoption. By the last, the hides are laid in a pack, or pile, and covered with tan, or other imperfect conductor of heat, in order to confine the heat generated by the spontaneous decomposition of the gelatine, or other substance of the skin, and roots of the hair.

To the investigation of this very important part of the tanning process, chemists seem to have given little, or no, attention; and the practical workman has derived from them no insight into the true nature of the operation, and, consequently, has not improved it to that extent which is desirable. The action of lime upon the texture of the skin, so far as the loosening of the hair is concerned, is not involved in much obscurity; but the other changes effected upon the hide, which remain permanent, and influence, to a considerable extent, the quality of the leather, have never been satisfactorily explained. Neither have the chemists yet been able to give any satisfactory elucidation of the mode of operation of the bate, (as technically termed,) which consists of a solution of the muriates of ammonia and soda, &c., from the excrements of pigeons and domestic fowls. That the muriates are decomposed by, and combine with, the lime, rendering it more soluble, is most probably the true explanation of that part of the process; but how the fermentation produced affects the quality of the leather is not clear, unless we suppose that a large portion of the gelatine and albumen of the hide are removed. Though this is highly probable, yet we believe it is not generally admitted by tanners.

The Hon. Gideon Lee, in his lectures on tanning, remarks, "I be-

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lieve much of the original gelatine of our hides is never combined with the tannin, but is wasted, actually extinguished, or incapacitated, or perhaps both, in the process of the manufacture; for I have not a doubt that, if it were possible to bring every particle of hide, the moment it is prepared for the handler, into conjunction with the tannin, as chemists are able to do with the solutions of both, the results would give nearly two hundred pounds (probably one hundred and eighty) of leather from one hundred pounds of perfectly dry hide, when cleansed from all extraneous appendages." "But, as this is impracticable—as we must retain the original organic form of the hide, in order to make leather of it—it becomes our business to devise and adopt such saving modes of process as will waste the least, and save the greatest, quantity of the gelatinous substance of the hide." No doubt a vast saving of the gelatinous parts, and, consequently, a much increased amount of leather, might be made by adopting new modes of preparing the hides for the liquors. Further, we can say with confidence, that such saving has been made, and the quantity of leather produced has very nearly approached that which chemists consider the greatest amount possible. "Saving," he truly remarks, "should be the order of the day," and we may add, that he who, by the application of scientific principles to the manufacture of leather, should thereby add to the value of the article produced, and, consequently, to the general comfort and wealth, should justly be considered a benefactor to his country. When we consider the immense amount which has been annually lost for ages, for all practicable purposes, we are appalled at the sum, and our surprise increases that tanners have not busied themselves to lessen this immense drain upon their profits.

Among the evils of the old process may be enumerated that which arose from the energetic action of the agents made use of, and the extreme caution necessary to be observed in their application. By this process, still extensively used, the dry hides are subjected to the operation of the fulling stocks, which, by their powerful action upon the fibres, soften and extend their particles, causing them to move on each other, and, we believe, if long continued, opening the pores, and removing a considerable portion of the soluble matter of the hide, causing that "softness, limberness, and thinness," which is sometimes complained of in leather which has been otherwise well managed. A certain degree of softness appears to be absolutely necessary for the proper action of the lime and bate, and for the just incorporation of the tannin with the hide. Against the liming process a strong objection may be brought, in its injurious action upon the particles of gelatine and albumen of the hide. That a substance so powerful in its affini-

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ties, and capable of decomposing so rapidly most animal matter, should act with injurious effects upon the moist, porous substance of the softened hide, can scarcely be doubted by any who have had any practical experience on the subject. The effects this agent produces in expanding and stretching the fibres of the hide, thereby drawing them from their original position, and, consequently, weakening their texture, must be obvious—"swelling, as it does, the body of the hide to double its original thickness." "Every tanner knows that high limed leather is loose, weighs light, and wears out quickly;" and may we not with much probability suppose, that its injurious effects are produced in a proportionate degree by the "low liming process?"

The evils resulting from the use of this agent are doubtless to be ascribed to its decomposition of the albuminous and gelatinous parts, and that thereby an amount of these substances is destroyed, of which we can form no adequate idea. Not only does the tanner thus lose those parts which would have combined and formed leather, but that which is formed is rendered less valuable, owing to its decreased solidity, toughness, and porosity.

Without doubt, the injurious effects produced by liming are increased and heightened by the after process of bating, which is intended to extract the lime, and bring down the skin to its original thickness, by soaking or drenching, as before alluded to. The muriates, &c., in solution, which render the lime more soluble, and thus easily removed, carry off a portion of the glue, &c., and the fermentation induced by the decomposition of the animal matters of the bate also materially assists in the destruction of these easily decomposed components of the hide. That a fermentation takes place, is proved by the rapid action of the bate in destroying the grain side of the skin, or hide, during the warm days of summer, if not properly attended, and suffered to proceed too far. Another objection which should not be passed over, lies in the extremely unpleasant scent arising from the putrefaction of animal matter, which is inseparably attached to the clothing and persons of the workmen engaged in this branch of the business.

The evils arising from the old, and still practiced, methods being thus made sufficiently apparent to the understanding of every practical man who has not already appreciated them, and learned from sad experience their reality, we are prepared for the reception of a process which, to a great extent, in the estimation of those who have applied it, removes the difficulties under which the tanner has labored. This is that which has been erroneously denominated the "cool sweating process for unhairing hides and skins," in contradistinction to that which is practiced in Europe, and, to some extent, in this

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country, and is called the "warm sweating," and which has been before described. It will be remembered that the effects produced by the latter method, in loosening the hair, are due to the putrefaction engendered by their being placed in piles, or exposed to artificial heat, and that it is attended with much risk.

The so-called "cool sweating process," and apparatus made use of, are thus described. First, a vault, or pit, should be prepared for the reception of the hides, which, for convenience sake, should be twelve feet long, twelve feet deep, and ten feet wide. The walls may be built of stone, or a frame, and planked. There should be an alley, or vestibule, for entrance, not less than six feet long, having a door at each end, the outer one made double, and filled in with tan, to prevent the communication of warm dry air from without. A ventiduct, made of plank, ten or twelve inches square, should extend from the centre of the bottom of the vaults, three or four rods therefrom, and placed not less than four feet below the surface of the ground. This serves both as a drain for discharging the water of the vault, and to admit damp, cool air, to supply the place of that which has become rarefied, and thus keep up a current through the ventilator at top. The ridge of the roof may be level with the surface of the ground; on the ridge, and extending its whole length, set up two planks, edgewise, two inches apart. The space between these is to be left open, but cover the remainder of the roof with earth to the depth of not less than three feet. The covering of earth upon the vault and drain is to preserve a low temperature for the hides, so that they may unhair without tainting. Spring water should be conducted, either in pipes or logs, around the angles formed by the ceiling with the walls of the vault, from which water should be allowed to flow in small quantities, either forming a spray, or falling so as to raise a mist, or vapor, and saturate the atmosphere of the vault. The temperature of spring water is generally about 50° Fahr. Water evaporating at all temperatures, it is plain that, if a constant supply be afforded, this evaporation, by requiring a large portion of heat, would keep the temperature of the vault nearly uniform. To suspend the hides in the pit, place three bars lengthwise, at equal distances, near the ceiling, with iron hooks, two or three inches apart, inserted therein. Soak the hides as usual for breaking, then hang them singly upon the hooks by the butt, spreading them fully open. In the course of a few days, when the hair begins to loosen upon the upper parts, take them down, raise the middle bar, and hang them by the other end until they will easily unhair. The hides should not be broken until they are taken from the vault, and ready to unhair. In a good vault, where the thermometer ranges from 44° to 56° Fahrenheit, which it should

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never exceed, and where there is a free circulation of *damp* air, hides generally require, for unhairing, from six to twelve days. When the temperature falls below 44°, the ventilator should be partially closed; and when it rises above 56°, *cold damp* air must be forced in, or an increased quantity of cold spring water may be thrown from a hose, or otherwise.

If this process is properly and carefully conducted, hides will be received by the tanner, from the beamsman's hands, free from all extraneous matter, and retaining nearly all their gelatine, or glue, with the albuminous and fibrous matter of the organized hide. The action of the agents employed in the cool sweating process appears to be confined to the *surface*, or *grain*, of the skin, expanding the outer portion, and softening the roots of the hair, thus rendering their extraction more easily effected. In opposition to some who, without due examination, have pronounced this a putrefactive process, and consider it as differing in no important particular from that formerly made use of, and which was attended with such imminent risk, we, after considerable experience and investigation, are brought to the conclusion that the effect produced by what is called the "cool sweating process," is due to the *softening* action of the vapor, and that it is a simple case of absorption and swelling of the tissues of the skin, and roots of the hair. Various circumstances combine to strengthen us in this opinion, the most obvious of which are the following, viz.: We believe it to be the opinion among chemists that the putrefactive fermentation, or that which is vulgarly called tainting, is always attended by the formation of ammonia, (spts. hartshorn, a substance readily perceived by the senses,) and that when this cannot be recognized in the vault, or chamber, in which the process is conducted, we are warranted in supposing it is not produced, and that, consequently, this fermentation does not take place. That the action of the vapor is confined to the surface of the hide, is proved by its increased weight, when prepared by this process, over that by liming, and the consequent gain of leather; for whereas, by the old liming method, thirty to forty per cent. gain upon the original weight of the dry hide was considered a good increase, now, by the cool sweating, a gain of from fifty to seventy, and even eighty, per cent. is often obtained—thus showing incontestably that a great amount of the softer portions of the hide, which were formerly lost, are now retained within it by this method of unhairing. This result would not to the same extent be produced, if the process was putrefactive, as thereby much of the substance must be removed, or brought into a condition to be acted upon by the solvents to which they are subjected. We may add, that

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those chemists who have attentively examined it, have pronounced it a simple case of absorption and softening.

The advantages which this process presents, must be apparent to the understanding of every unprejudiced practical tanner, who is at the same time acquainted with the chemical nature of the action of the substances used in his art. To the tanner, who believes that all the *glue* must be extracted from the hide in order to make good leather, this method would appear erroneous; but who, that has any knowledge of the composition of leather, so supposes? or who would consider the objection of such as worthy of regard?

The continuance of this method, where once adopted, is the best proof of its utility, and that it realizes, in practice, all that was expected of it. It is practiced almost universally in the large tanneries of New York, Maine, New Hampshire, and, to some extent, in northern Pennsylvania. Perhaps the best mode of illustrating the advantages to be derived from the process, will be from evidence given forth by tanners who have adopted it, rather than by expressions in general terms, unsupported by testimony. This mode of proof, though often deceptive, and, on that account, not much confided in, in this case will not be doubted, coming, as it does, from those who are known to the trade, and acknowledged by them to be men of honor and veracity.

Col. W. Edwards, who, as the Hon. Gideon Lee states, "has been the originator of many important improvements in the mechanical department of tanning," has certified that he has been a tanner for twelve years, and has tanned upwards of forty thousand sides per annum—has used this method, and knows that there was a saving of *two-thirds* the expense of working in, and *twenty-five per cent. gain* in weight over that produced by liming. And, moreover, that he has made diligent inquiry of tanners, from different parts of this country and Europe, and could never find a single instance where a similar mode was practiced.

John Spencer, of Onondaga county, N. Y., late member of the Legislature, states that "the hides are prepared for the bark with *half* the labor, and, when prepared, tan fully as fast, weigh heavier, and wear much longer, than when prepared by liming."

Thos. Updegraff, of Williamsport, tanner, states that "a tanner can accomplish as much in working in, in ten days, by this method, as could be done in one month by the old way of liming."

W. W. Edwards, of Hunter, Greene county, N. Y., testified that, by memoranda kept at the time, and accurately made up, the expense of working in, or preparing for the bark liquor, by the old liming process, was twelve and a half cents per side; and that the expense

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of the same operation by the new mode, as ascertained in the same manner, was four and two-thirds cents per side. That the hides were of similar kinds, and that all his leather was disposed of in New York, and that, if well manufactured, gains more in weight, is of superior texture, fineness, and solidity, if worked in by the sweating process, after being well softened, than by any liming process he has ever known.

E. J. Stimson, formerly (in 1835) of Hunter, Greene county, N. Y., testified that he had tanned, in four years, upwards of 75,000 sides of leather—that he made 62½ per cent. gain on Oronoco hides, 53 per cent. on Vera Cruz, 51 on Mexican, and 55 per cent. on Buenos Ayres, all of which were sent to New York market for disposal; and that the leather manufactured by this process gains more in weight, the proportion of sides stamped by inspectors "*damaged*," is less; also, that they will tan faster, if properly attended to, than when prepared by the liming process.

This mode of unhairing can be applied with like success to calf skins, and upper, as to sole, leather, with some modifications in the tanning; first proved by the late Ebenezer Shore, and brought into general use by Nathan T. Davis. The evidence of the successful application of these improvements, we have in the statements of the following tanners.

N. T. Davis, of Levant, Maine, says that he knows it to be as valuable for calf skins and upper, as for sole, leather, and that his leather has been pronounced of superior quality by the Boston consumers.

Benj. Cutter, of Jaffray, N. H., deposed that he has manufactured, for some years past, sole, upper leather, and calf skins—that he finds the calf skins gain fifteen per cent. more by weight of the manufactured stock, than by the liming process; and those to whom he has sold his skins, have pronounced them good.

Ezra W. Avery, of Grafton, N. H., states that calf skins and upper leather, prepared by this process, are more impervious to water, possess more toughness, strength, and durability, than by liming, and that he has fully tested its value by working, wearing, and selling it to his customers.

Other testimony could be produced, all confirming the above statements as regards the reduction of expense, the ease of working, and superiority of leather produced. But the above we considered sufficient to satisfy any unprejudiced tanner of the correctness of the process, confirmed as it is by hearsay evidence, which must have arrested his attention.

We would call the attention of the tanners of Pennsylvania and Maryland to the consideration of this subject. Its importance they

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cannot fail to perceive. Interest, that prime mover to action, should incite them to investigation. St. Paul has said, "Prove all things—hold fast to that which is good." Let not prejudice blind, or mistaken opinion lead you astray. We know that prejudice in favor of old methods is as deeply rooted in the mind of the tanner, as in that of the farmer. But, thanks to that free spirit of inquiry which has penetrated even the mysteries of agriculture, the day is opening when the tanner shall no longer acknowledge ignorance of the principles concerned in his art, and when true modes of procedure will take the place of those methods which have been shown to be erroneous, wasteful, and offensive. S. T.

On some Peculiar Changes in the Internal Structure of Iron, independent of, and subsequent to, the several Processes of its Manufacture. By Charles Hood, Esq., F.R.A.S., &c.*

The important purposes to which iron is applied have always rendered it a subject of peculiar interest; and at no period has its importance been so general and extensive as at the present time, when its application is almost daily extending, and there is scarcely anything connected with the arts, to which, either directly or indirectly, it does not in some degree contribute. My object in the present paper is to point out some peculiarities in the habitudes of iron, which appear almost wholly to have escaped the attention of scientific men, and which, although in some degree known to practical mechanics, have been generally considered by them as isolated facts, and not regarded as the results of a general and important law. The circumstances, however, well deserve the serious attention of scientific men, on account of the very important consequences to which they lead. The two great distinctions which exist in malleable wrought-iron are known by the names of "red-short" and "cold-short" qualities. The former of these comprises the tough, fibrous iron, which generally possesses considerable strength when cold; the latter shows a bright crystalized fracture, and is very brittle when cold, but works ductile while hot. These distinctions are perfectly well known to all those who are conversant with the qualities of iron; but it is not generally known that there are several ways by which the tough red-short iron becomes rapidly converted into the crystalized, and by this change its strength is diminished to a very great extent.

The importance which attaches to this subject, at the present time, will not, I think, be denied. The recent accident on the Paris and Versailles Railway, by which such a lamentable sacrifice of human life has occurred, arose from the breaking of the axle of a locomotive engine, and which axle presented, at the fractured parts, the appear-

* Read before the Institution of Civil Engineers, June 21, 1842, and communicated by the author to the twenty-first volume of the Philosophical Magazine, from which periodical we have extracted it.

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ance of the large crystals, which always indicate cold-short and brittle iron. I believe there is no doubt, however, that this axle, although presenting such decided evidence of being, at the time of this accident, of the brittle cold-short quality, was at no distant period tough and fibrous in the highest degree; and, as the French government have deemed the matter of sufficient importance to be inquired into by a special commission, I trust that some remarks on the subject will be interesting to the members of the Institution of Civil Engineers. I propose, therefore, to show how these extraordinary and most important changes occur, and shall point out some, at least, of the modes by which we can demonstrate the truth of this assertion by actual experiment.

The principal causes which produce this change are percussion, heat, and magnetism; and it is doubtful whether either of these means *per se* will produce this effect; and there appear strong reasons for supposing that, generally, they are all in some degree concerned in the production of the observed results.

The most common exemplification of the effect of heat in crystalizing fibrous iron, is by breaking a wrought-iron furnace bar, which, whatever quality it was of in the first instance, will, in a short time, invariably be converted into crystalized iron; and by heating, and rapidly cooling by quenching with water a few times, any piece of wrought-iron, the same effect may be far more speedily produced.

In these cases, we have at least two of the above causes in operation—heat and magnetism. In every instance of heating iron to a very high temperature, it undergoes a change in its electric, or magnetic, condition; for, at very high temperatures, iron entirely loses its magnetic powers, which return, as it gradually cools to a lower temperature. In the case of quenching the heated iron with water, we have a still more decisive assistance from the electric and magnetic forces; for Sir Humphrey Davy long since pointed out* that all cases of vaporization produced negative electricity in the bodies in contact with the vapor; a fact which has lately excited a good deal of attention, in consequence of the discovery of large quantities of negative electricity in effluent steam.

These results, however, are practically of but little consequence; but the effects of percussion are at once various, extensive, and of high importance. We shall trace these effects under several different circumstances.

In the manufacture of some descriptions of hammered iron, the bar is first rolled into shape, and then one-half the length of the bar is heated in a furnace, and immediately taken to the tilt-hammer and hammered; and the other end of the bar is then heated and hammered in the same manner. In order to avoid any unevenness in the bar, or any difference in its color, where the two distinct operations have terminated, the workman frequently gives the bar a few blows with the hammer on that part which he first operated upon. That part of the bar has, however, by this time become comparatively cold; and if this cooling process has proceeded too far when it receives this

* Davy's Chemical Philosophy, p. 188.

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additional hammering, that part of the bar *immediately* becomes crystalized, and so extremely brittle that it will break to pieces by merely throwing it on the ground, though all the rest of the bar will exhibit the best and toughest quality imaginable. This change, therefore, has been produced by percussion, (as the primary agent,) when the bar is at a lower temperature than a welding heat.

We here see the effects of percussion in a very instructive form. And it must be observed that it is not the excess of hammering which produces the effect, but the absence of a sufficient degree of heat at the time the hammering takes place; and the evil may probably be all produced by four or five blows of the hammer, if the bar happens to be of a small size. In this case we witness the combined effects of percussion, heat, and magnetism. When the bar is hammered at the proper temperature, no such crystalization takes place, because the bar is insensible to magnetism. But as soon as the bar becomes of that lower degree of temperature at which it can be affected by magnetism, the effect of the blows it receives is to produce magnetic induction; and that magnetic induction, and consequent polarity of its particles, when assisted by further vibrations from additional percussion, produces a crystalized texture. For it is perfectly well known that, in soft iron, magnetism can be almost instantaneously produced by percussion; and it is probable that, the higher the temperature of the bar at the time it receives the magnetism, the more likely will it be to allow of that re-arrangement of its molecules which would constitute the crystalization of the iron.

It is not difficult to produce the same effects by repeated blows from a hand-hammer on small bars of iron; but it appears to depend upon something peculiar in the blow, which, to produce the effect, must occasion a complete vibration among the particles in the neighborhood of the part which is struck. And it is remarkable that the effects of the blows, in all cases, seem to be confined within certain limited distances of the spot which receives the strokes. Mr. Charles Manby has mentioned to me a circumstance which fully bears out this statement. In the machine used for blowing air at the Beaufort Iron Works, the piston-rod of the blowing cylinder, for a considerable time, had a very disagreeable jar in its motion, the cause of which could not be discovered. At last the piston-rod broke off quite short, and close to the piston, and it was then discovered that the key had not properly fastened the piston and the rod together. The rod, at the fracture, presented a very crystalized texture; and, as it was known to have been made from the very best iron, it excited considerable surprise. The rod was then cut at a short distance from the fracture, and it was found to be tough and fibrous in a very high degree; showing what I have already pointed out, that the effects of percussion generally extend a very short distance. In fact, we might naturally expect, that, as the effect of vibration diminishes in proportion to the distance from the stroke which produces it, so the crystalization, if produced by this means, would also diminish in the same proportion. The effect of magnetism alone may also be estimated from this circumstance. The rod would, of course, be magnetic throughout

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its whole length, this being a necessary consequence of its position, independent of other circumstances; but the necessary force of vibration among its particles only extended for a short distance, and to that extent only did the crystalization proceed. The effect of magnetism in assisting the crystalization, I think it unnecessary to dwell upon, as the extensive use of galvanic currents in modern times has fully proved their power in crystalizing some of the most refractory substances; but, by themselves, they are unable to produce these effects on iron, or, at least, the operation must be extremely slow.

Another circumstance which occurred under Mr. Manby's observation confirms, generally, the preceding opinions. A small bar of good tough iron was suspended and struck continuously with small hand-hammers, to keep up a constant vibration. The bar, after the experiment had been continued for some considerable time, became so extremely brittle, that it entirely fell to pieces under the light blows of the hand-hammers, presenting throughout its structure a highly crystalized appearance.

The fracture of the axles of road-vehicles of all kinds is another instance of the same kind. I have, at different times, examined many broken axles of common road-vehicles, and I never met with one which did not present a crystalized fracture; while it is almost certain that this could not have been the original character of the iron, as they have frequently been used for years with much heavier loads, and at last have broken without any apparent cause, with lighter burdens and less strain than they have formerly borne. The effects, however, on the axles of road-vehicles are generally extremely slow, arising, I apprehend, from the fact that, although they receive a great amount of vibration, they possess a very small amount of magnetism, and are not subject to a high temperature. The degree of magnetism they receive must be extremely small, from their position and constant change with regard to the magnetic meridian, the absence of rotation, and their insulation by the wood-spokes of the wheels. Whether the effects are equally slow with iron wheels used on common roads, may perhaps admit of some question. With railway axles, however, the case is very different. In every instance of a fractured railway axle, the iron has presented the same crystalized appearance; but this effect, I think, we shall find is likely to be produced far more rapidly than we might at first expect, as these axles are subject to other influences, which, if the theory here stated be correct, must greatly diminish the time required to produce the change in some other cases. Unlike other axles, those used on railways rotate with the wheels, and, consequently, must become, during rotation, highly magnetic. Messrs. Barlow and Christie were the first to demonstrate the magnetism by rotation produced in iron, which was afterwards extended by Messrs. Herschel and Babbage, to other metals generally, in verifying some experiments by M. Arago. It cannot, I think, be doubted that all railway axles become, from this cause, highly magnetic during the time they are in motion, though they may not retain the magnetism permanently. But, in the axles of locomotive engines, we have yet another cause which may tend to increase the effect. The

vaporization of water and the effluence of steam have already been stated to produce large quantities of negative electricity in the bodies in contact with the vapor; and Dr. Ure has shown* that negative electricity, in all ordinary cases of crystalization, instantly determines the crystaline arrangement. This, of course, must affect a body of iron in a different degree to that of ordinary cases of crystalization; but still we see that the effects of these various causes all tend in one direction, producing a more rapid change in the internal structure of the iron of the axle of a locomotive engine, than occurs in almost any other case.

Dr. Wollaston first pointed out that the forms in which native iron is disposed to break, are those of the regular octahedron and tertrahedron, or rhomboid, consisting of these forms combined. The tough and fibrous character of wrought-iron is entirely produced by art; and we see in these changes that have been described, an effort at returning to the natural and primal form—the crystaline structure, in fact, being the natural state of a large number of the metals; and Sir Humphrey Davy has shown that all those which are fusible by ordinary means, assume the form of regular crystals by slow cooling.

The general conclusion to which these remarks lead us, appears, I think, to leave no doubt that there is a constant tendency in wrought iron, under certain circumstances, to return to the crystalized state; but that this crystalization is not necessarily dependent upon time for its development, but is determined solely by other circumstances, of which the principal is undoubtedly vibration. Heat, within certain limits, though greatly assisting the rapidity of the change, is certainly not essential to it; but magnetism, induced either by percussion, or otherwise, is an essential accompaniment of the phenomena attending the change.

At a recent sitting of the Academy of Sciences at Paris, M. Bosquillon made some remarks relative to the causes of the breaking of the axle on the Versailles railroad; and he appears to consider that this crystalization was the joint effect of time and vibration, or, rather, that this change only occurs after a certain period of time. From what has here been said, it will be apparent that a fixed duration of time is not an essential element in the operation; that the change, under certain circumstances, may take place instantaneously; and that an axle may become crystalized in an extremely short period of time, provided that vibrations of sufficient force and magnitude be communicated to it. This circumstance would point out the necessity for preventing, as much as possible, all jar and percussion on railway axles. No doubt one of the great faults of both engines and carriages of every description—but particularly the latter—is their possessing far too much rigidity; thus increasing the force of every blow produced by the numerous causes incidental to railway transit, by causing the whole weight of the entire body in motion to act by its momentum, in consequence of the perfect rigidity of the several parts, and the manner of their connexion with each other, instead of such a degree of elasticity as would render the different parts nearly inde-

* Journal of Science, vol. v, p. 106.

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pendent of one another, in the case of sudden jerks, or blows; and which rigidity must produce very great mischief, both to the road, and to the machinery moving upon it. The looseness of the axles in their brasses must also be another cause which would greatly increase this evil.

Although I have more particularly alluded to the change in the internal structure of iron with reference to the effects on railway axles, it need scarcely be observed that the same remarks would apply to a vast number of other cases, where iron, from being more or less exposed to similar causes of action, must be similarly acted upon. The case of railway axles appears to be of peculiar and pressing importance, well deserving the most serious consideration of scientific men, and particularly deserving the attention of those connected with railways, or otherwise engaged in the manufacture of railway machinery, who have the means of testing the accuracy of the theory here proposed. For if the views I have stated be found to harmonize with the deductions of science, and to coincide with the results of experience, they may have a very important effect upon public safety. It may be observed, on the other hand, however, that, at the present time, all railway axles are made infinitely stronger than would be necessary for resisting any force they would have to sustain in producing fracture, provided the iron were of the best quality; and to this circumstance may perhaps be attributed the comparative freedom from serious accidents by broken axles. The necessity for resisting flexure and the effects of torsion, are reasons why railway axles never can be made of such dimensions only as would resist simple fracture; but it would be very desirable to possess some accurate experiments on the strength of wrought iron in different stages of its crystalization, as there can be no doubt that very great differences exist in this respect; and it is probable that, in most cases, when the crystalization has once commenced, the continuance of the same causes which first produced it goes on continually increasing it, and thereby further reduces the cohesive strength of the iron.

[Several samples of broken railway axles accompanied this paper, and were exhibited at the meeting. In some of them, the same axle was broken in different places, and showed that, where the greatest amount of percussion had been received, the crystalization of the iron was far more extensive than in those parts where the percussion had been less.]

Remarks.—Mr. Moreland had frequently noticed that pins for chains, and pump-rods, although made of the best iron, would, if subjected to concussion, after a certain time, break suddenly, and that the fracture would exhibit a large crystalized texture. This was also frequently observed in the broken axles of road carriages, although they were generally made of iron of the finest quality.

Mr. E. Woods had observed the crystalized fracture in all the broken axles on railways which he had seen.

Mr. Hood exhibited some specimens of broken axles, all of which showed a large crystalized fracture; he believed that the iron from

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which the majority of them had been made was of the best quality, and in the parts not immediately subjected to concussion the fracture was quite different. One of them had been in use only three months, and had become so brittle, that, on attempting to break it, it jarred off the shoulder of the journal, although an incision was made all round at the spot where it was intended to be broken.

Mr. York would account for the tendency of the axles to break at the journal, by that part being subjected, during the process of forging, to more hammering than the body.

Mr. Hood agreed that such might be the case, but he conceived that it was more probably produced by cold hammering. He had taken a sample from the body of a broken cranked axle, from the Grand Junction Railway, the iron of which was evidently of the best quality; but at the point of fracture, which was certainly at that part where it had been most hammered, the fracture presented a large crystalized texture.

A large anchor, which had been in store for more than a century at Woolwich Dock-yard, and was supposed to be made of extremely good iron, had been recently tested as an experiment, and had broken instantly with a comparatively small strain; the fracture presented very large crystals. In this case, he believed the length of time which the anchor had remained in the same position had produced the same effects as magnetism and vibration.

Mr. Lowe stated that at the gas-works under his direction, wrought iron fire-bars, although more expensive, were generally preferred; a pan of water was kept beneath them, the steam from which would speedily cause them to become magnetic. He had frequently seen these bars, when thrown down, break into three pieces, with a large crystalized fracture.

Mr. Miller had frequently seen, in manufactories, that when the smiths had forged parts of engine-work which, from their intricate forms, required to be much hammered, the ends were jarred off while they were being worked upon. He instanced particularly the side rods of the engine for the "Lord Melville" steamer, of which, while shutting up the middle, one of the ends of each rod was jarred off, and presented large crystals in the fracture; being well assured of the good quality of the iron in the rods, he had the same welded on again, and, although the circumstance had occurred twenty years since, they were still at work, and had not shown any symptoms of weakness. It must be evident that, in this case, the fracture and the crystalized appearance of the metal must have been produced by the cold hammering to which it had been subjected.

Mr. York agreed with Mr. Hood in the fact of a change taking place in the texture of the iron, but he was of opinion that it more frequently occurred during, than after, manipulation; he alluded more particularly to railway axles, in which he believed the injury to be done by the cold hammering, or planishing, after they were faggoted; he had frequently seen one end of an axle fall off while the other was being hammered. In all such cases, and in those of accidental break-

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age, such as recently occurred on the Versailles Railway, and in other places, the fracture always presented a crystalized appearance.

He then exhibited and described a railway axle, which he stated to possess the combined advantages of rigidity and toughness, and avoiding entirely the crystalization of the iron during the process of manufacture; this he described to be effected by maintaining the axle in a hollow state during the whole operation of hammering, thereby avoiding the vibration and concussion, to which cause he attributed the crystalization of the iron in solid axles, being of opinion that the repeated blows of the hammer on a solid mass, particularly during the process of "planishing," were the chief, if not the only, cause of the ductile quality of the iron being destroyed. He stated that he had made numerous experiments for the purpose of ascertaining this fact, and in every instance, when the axle was sound, the iron presented the same crystalized fracture, although the bars, previous to their being welded together, were of the most fibrous quality; but, if the axle was not quite sound, and the bars not perfectly welded to the centre, then the fracture was somewhat fibrous, the axle being partially hollow, and thereby avoiding the vibration to a considerable extent. This fact suggested to him the propriety of keeping the axle hollow; and the mode of manufacture he described to be by taking two dished half-cylindrical bars of iron, of the entire length of the axle, putting them together, and welding them under a hammer in swages, by which means the particles are not driven asunder by the heavy blows, and the axle, or faggot, lengthened, but are driven together, and towards the centre. The axles produced by this means, he stated to be as perfectly ductile as the bars in the first instance. A further advantage he stated to consist in being able to make half the whole length of the axle at one heat, thereby avoiding, to a considerable extent, the danger of burning the iron by repeatedly heating it; the iron in the axle he described as being an uniform cylinder in thickness, and, consequently, requiring an uniform heat, whereas the external bars of a faggot for a common axle were liable to be burnt, before the centre was heated to a welding state. The diameter of the hollow axle was increased from 3½ inches (the general size of a solid axle) to 4 inches, in order to give a proper degree of rigidity, but without increasing the weight.

The usual proof to which solid railway axles were subjected, was by allowing a weight of six cwt. to fall upon them from a height of nine feet; with that force they were frequently broken at the second blow, and sometimes by the first—he had tried some of the hollow axles, by letting fall upon them a weight of ten cwt. from a height of fifteen feet, without breaking one of them. Edin. N. Philos. Jour.

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The Practice of Fresco Painting.

Extracts from Appendix to Report of Commissioners on Fine Arts, for decorating the new House of Commons.

[Continued from Page 62.]

Various Communications on Fresco Painting.

The following papers contain further information respecting the practice of fresco painting, or point out the sources where the subject is more fully treated. In inserting these communications and extracts, it has not been possible to avoid occasional repetition; but, in some cases, coïncident testimony may be necessary to establish or recommend particular methods. While the question respecting the adoption of fresco remains, for the reasons before stated, undecided, it may appear premature to describe its methods so fully; but it is precisely because so little is generally known of the process in this country, that it has been thought desirable to take this means of putting the artists and the public in possession of the information that has been collected.

A communication on fresco by Professor Hess, of Munich, (to Mr. William Thomas,) need not be given at length, as it agrees generally with the foregoing statements by Director Cornelius. In speaking of the preparation of the wall, Professor Hess recommends "bricks well dried, and of equal hardness," as the groundwork of the mortar and plaster. Mr. Thomas observes, "all the frescos in Munich are painted on the (plastered) brick wall: laths, with wattling and copper nails, are not approved of, as the risk of bulging is thus increased. The use of laths is sometimes necessary for certain surfaces, but the professors in Munich are decided that a brick ground is to be preferred wherever it is practicable, not only on account of its solidity, but also because it is better adapted for the execution of the painting. The brick ground absorbs superfluous water, and keeps the plaster longer in a fit state for painting upon. The painting ground dries much quicker on laths, as two surfaces are presented for evaporation. The walls ought to be thoroughly dry. A wall of a brick, or a brick and a half, in thickness, is preferable to paint upon. Professor Hess once observed to me, that where the walls in the lower portions of buildings were five or six feet thick, the liability of saline matter making its appearance was much increased, as the mass of wall remains longer in a humid state."

Mr. C. H. Wilson, professor of ornamental design in the Royal Edinburgh Institution, has contributed much useful information on the subject of fresco, derived from his own observation in Italy, and from recent communication from his father, Mr. Andrew Wilson, now at Genoa. He observes: "In Italy, the practice of lathing *walls* is unknown, but many of the finest Italian *ceiling* frescos are on lath, and are in perfect condition. Most vaulted ceilings in what is termed the *piano nobile*, or principal floor of every palace, are constructed of wood. The lathing, in this case, is not attached to single thin pieces of timber, cut to the shape of the ceiling, but to a strong grating; in

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some cases, the ribs and transverse pieces of this grating are four inches thick each way. The lathing in Italy is a very peculiar process. The material is the reed, which is cultivated so extensively in that country, and used in so many ways. It grows to the length of about eighteen feet, and is rather more than one inch and a quarter diameter at the base. When these reeds are used for lathing, they are split, and, not being strong enough for the purpose in this state, they are wattled upon the grating. The result of this somewhat complicated contrivance is a framework of great strength."

Mr. Hamilton, a distinguished architect of Edinburgh, observes:—"In the preparation of walls and ceilings for fresco painting, no expense should be spared; battens and lath are obviously perishable materials, and therefore ought to be avoided. The damp from exterior stone walls may be guarded against by lining them with brick; and, now that the use of cast iron is so well understood, the girders, or joisting, of houses where fresco painting is contemplated, should be of iron, arched with brick between, and thus a perfectly level ceiling may be formed of the most durable kind." For the more effectual prevention of damp, Mr. Hamilton recommends that the lining of brick should be somewhat detached, leaving a small space between it and the stone wall, to which it could be bound at intervals. Mr. C. Wilson, in communicating this opinion, remarks, that as the brick lining, added to walls of sufficient solidity for the support of the ceiling here described, would diminish the size of the rooms, tiles placed edgewise might be used instead of bricks. These should, however, be of sufficient strength to be in no danger of fracture from any ordinary accident. To guard against damp from roofs, or even occasional washing of upper floors, it is also suggested that a coating of asphalte might be applied on the upper sides of the arches of the ceiling. In some cases, asphalte might be necessary in walls. Mr. C. Wilson observes, that a French architect, M. Polonceau, effectually checked the progress of damp from a humid soil, in several instances, by covering the horizontal surface of the masonry, a few inches above the level of the soil, with a coating of liquid asphalte, applied with a brush; when this was dry, it was covered with a layer of coarse dry sand, and the building then proceeded. An external joint of hard asphalte at the same level is necessary effectually to cut off all communication of damp. (See the "Revue Générale de l'Architecture," Septembre, 1841.) These and other remarks on the construction of walls and ceilings have been communicated with all deference to the judgment and experience of the architect of the new buildings at Westminster.

In considering the question respecting the comparative fitness of laths and bricks, as a groundwork for fresco, it is not to be forgotten that the battened wall sooner adapts itself to the temperature of the atmosphere, and is, therefore, less likely to be affected by external damp; while the coldness of the more solid wall causes the rapid condensation of moisture in humid weather. This evil might be guarded against by due precautions with regard to temperature and ventilation.

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Mr. C. Wilson next describes the mode of preparing the lime at Genoa: "The lime having been slaked is mixed in a trough, about six feet in length and twenty inches in width; at the bottom it is somewhat narrower. The instrument used in mixing it is similar to that used by our masons. The lime is worked with this, and water is thrown in till the substance is of the consistence of cream. At the end of the trough there is a little sluice, the opening of which, however, comes only to within an inch and a half of the bottom of the trough. On being drawn up, the sluice allows the lime to escape, but small stones, or impurities, which may have sunk to the bottom, are prevented from passing by the ledge under the opening. The lime is received in a pit dug in the mere earth, (not lined,) to the depth of several feet, and of any convenient size. The process of mixing in the trough is repeated till the pit is well filled, the trough being washed out with clean water every third or fourth mixing.

"The lime, being thus prepared, is left in the pit from *eight to twelve months*,* according to its ascertained strength. The lime for the first rough coat need not be kept more than two months; this is allowed to dry perfectly, before the next coats are put on. The proportion of sand to lime is the same as with us, viz., two of sand and one of lime. No hair is used by the Italian plasterers. The lime of which the *intonaco*, or coat of fine plaster, is composed, is, however, to be subjected to a much more careful preparation than that used for the first coat. After it has been kept the requisite time, it is taken out with a spade, the greatest care being necessary not to come too near the edges, sides, or bottom, of the pit, lest any clay, or earth, should be taken up with the lime. It is now thrown again into the troughs, and is again thoroughly mixed with water, till it is not thicker than milk; it is then allowed to escape as before through the open sluice, but this time it passes through a fine hair sieve into an earthenware jar; a number of these jars are required, and each is filled to within a third of the top. The lime is allowed to settle, and, when the water which rises over its surface is clear, it is poured off. This is repeated till there is no more water to pour off, and the lime remains in the jar of the consistence of the white paint commonly used, and is quite as smooth. It is now ready to be mixed for the *intonaco*, which consists, as usual, of two parts sand and one of lime. Great pains are taken in Italy to find a suitable sand; it must be perfectly clean, sharp sand, the grains of equal size, and its color favorable, as the *intonaco* should not be too dark. The presence of any earthy particles in the plaster would inevitably ruin the fresco; this accounts for the very careful preparation which all the materials used undergo."

Professor Hess recommends avoiding the intermixture of plaster of Paris in the mortar for the first rough coat, (in the finer coats it is never employed as a preparation for fresco,) and advises a moderate use of small flint pebbles. The rough coat should not be too com-

* In Florence, where fresco painting is now occasionally practiced, artists are of opinion that "the lime should be kept in the moist state from eight to twelve months, otherwise it will burn both colors and brushes." (Letter from Mr. Seymour Kirkup, Florence, 1842.)

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pactly laid on, as its porousness is essential to the convenience of fresco painting. In like manner, the last finer coats should be lightly floated on to ensure their power of absorption. He proceeds: "The plaster for painting on is composed of lime, not in too caustic a state, and pure quartz sand. With regard to the lime, it should be well and uniformly manipulated, and should be entirely free from any small hard lumps. The sand should be very carefully washed, to cleanse it from clayey or saline particles, and should be afterwards dried in the open air. Sand that is coarse, or unequal in grain, should be sifted; thus the plaster will be uniform in its texture. The proportion of sand to the lime is best learned from experience, and must depend on the nature of the lime. If the plaster contains too much lime, it becomes incrusted too soon, is too smooth in its surface, and easily cracks; if it contains too little, it is not easily floated, the successive patches (as the fresco proceeds) are not to be spread conveniently in difficult situations, and the plaster is not so lasting."

"Before laying on the plaster, the dry rough coat is wetted with a large brush again and again, till it will absorb no more. Particular circumstances, such as spongy bricks in the wall, humid or very dry weather, &c., dictate the modes in which this operation is to be regulated. The plaster should be laid on lightly and freely with a wooden hand-float; in connecting the successive patches, some portions require, however, to be finished with an iron trowel; in this case, care must be taken not to press too strongly, otherwise rust spots might appear in the lime, and even cause portions of the superadded painting to become detached. [A glass float seems to be preferable where a wooden instrument is unfit.] The plaster should be about a quarter of an inch in thickness. The surface of the last coat is then slightly roughened, to render it fit for painting on. The wall, thus prepared, is to be left a quarter, or half, an hour before beginning to paint."

The colors enumerated by Professor Hess are the following:— "White: lime which has either been long kept, or, by repeated manipulations and drying, is rendered less caustic. Yellow: all kinds of ochres, terra di Siena. Red: all kinds of burnt ochres, burnt terra di Siena, [the brightest particles selected at different stages of the process of burning, furnish, according to Director Cornelius, very brilliant reds,] oxides of iron, and lake-colored burnt vitriol. Brown: umber, raw and burnt, and burnt terra vert. Black: burnt Cologne earth, which, when thus freed from its vegetable ingredients, affords a pure black. Purple: burnt vitriol, cobalt blue, and lake-colored burnt vitriol. Green: Verona green, (terra vert,) cobalt green, and chrome green. Blue: ultramarine, cobalt, and the imitation of ultramarine; the last is most safely used for flat tints, but does not always mix well with other colors. These colors have been well tested, and for the most part admit of being mixed in any way. Other more brilliant colors, such as chrome yellow, vermilion, &c., have been tried in various ways, but have not yet, in every case, been found to stand. Colors prepared from animal and vegetable substances cannot be used at all, as the lime destroys them." Fresco painters observe

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that "great attention is necessary in the due preparation of tints on the palette, for, if tints are mixed as the work proceeds, the painting, when dry, will appear streaky; when the colors are wet, the differences are not so perceptible."

In addition to hog's hair tools, which, as before observed, are longer than those used in oil painting, "small pencils of otter hair, in quills, are used. No other hair resists the lime, but becomes either burnt, or curled. The palette, of the material and form before described, is covered with a light colored varnish, to protect the tin from rust. Rain water, (that has not passed through an iron tube,) boiled or distilled water should be used, from first to last, in all the operations of fresco painting."

Professor Hess continues: "After the painter has laid in his general color, he should wait half an hour, or an hour, accordingly as the color sets, before he proceeds to more delicate modeling. In these first operations, he should avoid warm or powerful tints, as these can be added with better effect as the work advances. After the second painting and another pause, the work is finished with thin glazings and washings. Thus the requisite degree of completion can be attained, provided the daylight, and the absorbing power of the plaster, last. But, if the touches of the pencil remain wet on the surface, and are no longer sucked in instantaneously, the painter must cease to work, for henceforth the color no longer unites with the plaster, but, when dry, will exhibit chalky spots. As this moment of time approaches, the absorbing power increases, the wet brush is sucked dry by mere contact with the wall, and the operation of painting becomes more difficult. It is, therefore, advisable to cease as soon as these indications appear."

"If the wall begins to show these symptoms too soon, for example, in the second painting, some time may be gained by moistening the surface with a large brush, and trying to remove the crust, or setting, that has already begun to take place; but this remedy affords but a short respite. In the additions to the painting on successive days, it is desirable to add the new plaster to that part of the work which is not quite dry, for, if added to dry portions, the edges sometimes exhibit spots. Various other effects sometimes take place from causes that cannot be foreseen, and the remedies must be provided by the ingenuity of the artist, as the case may require."

The following extract from a letter addressed by Mr. Andrew Wilson to his son, (in March last,) will render the process of painting in fresco more intelligible; but it is almost needless to observe, that, in such details, the practice of painters may vary considerably.

"I lately went to the royal palace (Genoa) to see the Signor Pasciano paint a ceiling in fresco. His tints had all been prepared before my arrival; he had only two in pots, viz., pure lime, and a very pale flesh tint. He had no palette, but a table with a large slate for the top; on it he set round, 1. Terra vert. 2. Smalt. 3. Vermilion. 4. Yellow ochre. 5. Roman ochre. 6. Darker ochre. 7. Venetian red. 8. Umber. 9. Burnt umber. 10. Black. These colors were all pure, mixed only with water, and rather stiff; put down with a

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palette knife, perhaps about an ounce, or two at most, of each. He mixed each tint as he wanted it, adding to each from the pot of flesh tint, or that of white. Near him lay a lump of umber, and, on taking up a brushful of color, he touched this with it; the earth instantly absorbed the water, and he was thus enabled to judge of the appearance which the tint would present when dry. The painter used a resting-stick with cotton on the top, to prevent injury to the *intonaco.* The *intonaco* being prepared in the manner which I have described, the moment it would bear touching, he set to work. The head was that of the Virgin; he began with a pale tint of yellow round the head for the glory, (the color of the ground, owing to the mixture of sand with the lime, it is to be remembered, is a cool middle tint;) he then laid in the head and neck with a pale flesh color, and the masses of drapery round the head and shoulders with a middle tint, and with brown and black in the shadows. He next, with terra vert and white, threw in the cool tints of the face; then, with a pale tint of umber and white, modeled in the features, covered with the same tint where the hair was to be seen, and with it also indicated the folds of the white veil. All this time he used the colors as thin as we do in water colors; he touched the *intonaco* with great tenderness, and allowed ten minutes to elapse before touching the same spot a second time. He now brought his colored study, which stood on an easel, near him, and began to model the features, and to throw in the shades with greater accuracy. He put color in the cheeks, and put in the mouth slightly, then shaded the hair and drapery, deepening always with the *same* colors, which became darker and darker every time they were applied, as would be the case on paper, for instance. Having worked for half an hour, he made a halt for ten minutes, during which time he occupied himself in mixing darker tints, and then began finishing, loading the lights, and using the colors much stiffer, and putting down his touches with precision and firmness; he softened with a brush with a little water in it. Another rest of ten minutes; but, by this time, he had nearly finished the head and shoulders of his figure, which, being uniformly wet, looked exactly like a picture in oil, and the colors seemed blended with equal facility. Referring again to his oil study, he put in some few light touches in the hair, again heightened generally in the lights, touched too into the darks, threw a little white into the yellow round the head, and this portion of his composition was finished, all in about an hour and a half. This was rapid work; but you will observe that the artist rested *four times,* so as to allow the wet to be sufficiently absorbed into the wall to allow him to repass over his work."

"The artist now required an addition to the *intonaco;* the tracing was again lifted up to the ceiling, and, the space to be covered being marked by the painter, the process was repeated, and the body and arms of the Madonna were finished before I left him, at one o'clock."

The following is an extract from a second letter:—"Yesterday I went again to see Pasciano, and I found that he had cut away from his tracing, or cartoon, those parts which he had finished upon the ceiling; in fact, I now found it cut into several portions, but always

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carefully divided by the outline of figures, clouds, or other objects. These pieces were, in some instances, a good deal detached from each other, and were nailed to the plaster, so as to fold inwards, or outwards, for pouncing the outlines. The *intonaco* had just been fresh laid for the upper half of an angel supporting the feet of the Madonna. This was one of a group much larger than those surrounding the glory, and, therefore, requiring more color and finish; more than half of the figure, too, was in shadow, with a strong ray of light on the face and on one of the arms: this was a good opportunity of observing the painter's management of shadow. Having gone over the outline carefully with a steel point, he waited till the *intonaco* became a little harder, and, in the mean time, mixed up a few tints; he then commenced with a large brush, and went over the whole of the flesh; he next worked with a tint which served for the general mass of shadow, for the hair, and a slight marking out of the features. He now put a little color into the cheeks, mouth, nose, and hands, and all this time he touched as lightly as he possibly could, not to wash up the *intonaco.* He then halted for ten minutes, looking at his oil study, and watching the absorption of the moisture; and he called my attention to his outline—none of it was effaced by this washing.

"The *intonaco* would now bear the gentle pressure of his fingers, and, with the same large brush, but with water only, he began to soften and unite the colors already laid on. Observe, he had not as yet used any tint thicker than a wash of water color, and he continued to darken in the shadows without increasing the force, or depth, of color. This I before noted to you, that you can strengthen by the simple repetition of tint; but, if the day be very dry, after an hour or two this process of repeating with the same tint produces an opposite effect, and, instead of drying darker, it actually dries lighter. [See this explained in the communication by Professor Hess.] I now observed that the painter had increased the number of his tints, and that they were of a much thicker consistence; and he now began to paint in the lights with a greater body of color, softening them into the shades with a dry brush, or with one a little wet, as he required. In drying, the water comes to the surface, and actually falls off in drops; but this does no harm whatever to the work, although it sometimes looks alarming."

Mr. C. Wilson observes that the Aurora of Guido, in the Rospigliosi palace, in Rome, was painted on a copper trellis, and afterwards fixed on the ceiling, where it still exists. He adds that this fresco was offered for sale about fifteen years since, and that its safe removal was guaranteed. Mr. W. Thomas states that some small (landscape) frescos by Professor Rottman, in the Hofgarten in Munich, were painted on an iron frame and wire-work, and fixed in their situation afterwards. The example of Guido's Aurora, the figures of which are larger than life, shows that it would be possible to prepare movable frescos for situations where this might be thought necessary—for example, before flues, or tubes, in walls. But it is to be remarked that flues behind frescos have generally injured them. Mr. Aglio, who painted some frescos at Manchester some years since, attributes the

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great alteration of the colors in them, partly, to this circumstance, but also to his having been supplied with lime that was much too fresh. Cavaliere Agricola, in examining the frescos of the Vatican, found that the "Heliodorus" had suffered considerably from a flue behind it. The plaster had been detached from the wall, and projected, in some places, nearly four inches; it had been secured with nails, and the cracks had been filled with some composition, by Carlo Maratti, in 1702. The fresco of the "Defeat of the Saracens at Ostia" has been injured, in like manner, by a chimney behind it.

In connexion with the subject of movable frescos, it may be observed that the operation of detaching the mere painting from the wall, almost independently of the plaster, has been often practiced with success. Although less immediately connected with the present inquiry, it is desirable to make this process known, as, in repairing churches, and other buildings, in England, many ancient paintings on plaster have been destroyed, from ignorance as to the means of removing them. Mr. Ludwig Gruner gives the following account of the mode in which he detached some frescos at Brescia, in 1829. The convent of St. Eufemia, in that city, was then undergoing repair, and the excellent frescos it contained, painted by Lattanzio Gambara, in the sixteenth century, would have been destroyed, when Mr. Gruner succeeded, with the assistance of some expert Italians, in removing them from the walls. The mode they adopted was, first, to clean the wall perfectly; then to pass a strong glue over the surface, and, by this means, to fasten a sheet of fine calico on it. The calico, after having been riveted to the irregularities of the wall,* was afterwards covered with glue in like manner, and on it was fastened common strong linen. In this state heat was applied, which caused the glue even on the fresco to sweat through the cloths, and to incorporate the whole. After this, a third layer of strong cloth was applied on a new coat of glue. The whole remained in this state two or three days, (the time required may vary according to the heat of the weather.) The superfluous cloth extending beyond the painting was now cut off, so as to leave a sharp edge; the operation of stripping, or rolling, off the cloth begins at the corners, above and below, till at last the mere weight of the cloth, and what adhered to it, assisted to detach the whole, and the wall behind appeared white, while every particle of color remained attached to the cloth. This operation shows that the colors in fresco do not penetrate very deeply; the layer of pigment and lime which was detached in this instance was extremely thin—the outlines, and even the colors of masses, were visible at the back of the cloth. It is the opinion of some of the Munich professors that frescos thinly painted are least liable to change; the example just given, exemplifying, as it does, the practice of a skilful Italian fresco painter, seems to confirm this; but, in many instances, the surface of frescos, even by the older masters, is solidly painted. To

* Mr. A. B. Johns, of Plymouth, suggests fastening one or two layers of blotting paper on the surface of the painting at first, not only because that material may be made to adhere more closely to the wall, but because it is more easily detached by moisture, together with the cloths, when the painting is re-transferred to a new surface.

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transfer the painting again to cloth, in completing the operation above described, a stronger glue is used, which resists moisture, it being necessary to detach the cloths first used, by tepid water, after the back of the painting is fastened to its new bed.

The frescos by Paul Veronese, in the Morosini Villa, near Castel Franco, were removed by Count Balbi, of Venice, a few years since; he fastened cloth to the wall with a paste composed of beer and flour, and riveted it to the irregularities of the surface by means of a hammer composed of bristles. Several of these works, when re-transferred to canvas, were sold in England in 1838. The operation of removing frescos has been lately performed with success in Florence, and elsewhere.*

(To be continued.)

Comparison between the Strength and Deflection of the Ystalyfera Iron, made with Cold Blast and Anthracite, and some Experiments made with the same Iron, manufactured with Hot Blast. Bars five feet long, one inch square; the supports four feet six inches apart.

	Breaking weight.	Deflection.	Force to resist impact
	lbs.	lbs.	lbs.
Ystalyfera cold blast iron, from furnace,	618½	1.988	1297
" hot blast iron, re-melted as per Mr. Evans' second table of experiments,	496	1.632	821
Cold blast stronger than hot,	122½	.356	476
Equal to per cent.	24.6	21.8	57.9
Ystalyfera cold blast iron, re-melted in cupola with anthracite,	674	2.030	1373
" hot blast, re-melted by Mr. Evans	496	1.632	811
Cold blast stronger than hot,	178	.398	562
Equal to per cent.	35.8	24.3	69.25
Ystalyfera cold blast iron, re-melted in air-furnace,	660	1.760	1162
" hot blast, per Mr. Evans,	496	1.632	811
Cold blast stronger than hot,	164	.128	351
Equal to per cent.	33.5	.8	43.25

* The following publications may be consulted for further information on this subject:—Leopoldo Cicognara, del distacco delle pitture a fresco. Articolo estratto dall' Antologia di Firenze, 1825. Vol. 18, num. 52.—Girolamo Baruffaldi, Vita di Antonio Contri, pittore e rilevatore di pitture dal muro. Venezia, 1834.—Cenni sopra diverse pitture staccate dal muro e transportate su tela, &c. Bologna, 1840.

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N. B.—I have, to avoid prolixity, taken the middle table of Mr. Evans for reference, as the nearest approach to a correct mean of the qualities of the iron operated on—viz., Nos. 1, 2, and 3. His summary is—

	Breaking weight.	Deflection.	Impact.
Table of No. 1 experiment,	444½ lbs.	1.834	821
" 2 "	496 "	1.632	811
" 3 "	533 "	1.640	916

Having clearly established the superior strength of the Ystalyfera pig-iron, made with cold blast, more particularly in reference to the experiments of Mr. Tredgold, and those of Mr. Evans, I have next abstracted Mr. Fairbairn's Table of General Results, and, as nearly as possible, arranged and divided them into two classes, viz.: Experiments with Hot Blast Iron, and Experiments with Cold Blast Iron. The abstract of results of the hot blast iron, I find to be as follows:

Average breaking weight of the five feet bars, the supports being 4 feet 6 inches apart,	lbs.	445
Average deflection,		1,537
Strength to resist impact,		690
Cold blast—breaking weight,	lbs.	455
" average deflection,		1.612
" strength to resist impact,		734

These results enable me to make the following comparisons:

General average of the Ystalyfera cold blast, five feet bars, in breaking weight,	lbs.	644¼
Breaking weight of similar bars, hot blast, from Mr. Fairbairn's table,	lbs.	445
Ystalyfera iron stronger by	lbs.	199¼

—equal to $44\frac{7}{10}$ths per cent.

As there is only 10 lbs. between the breaking weight of the cold and hot blast in Mr. Fairbairn's table, any separate statement of the fact I consider unnecessary.

Ystalyfera cold blast—average deflection of the five feet bars,	lbs.	1.916
Deflection of hot blast iron from Mr. Fairbairn's table,		1.537
Difference in favor of Ystalyfera iron,	lbs.	.379

—equal to $26\frac{6}{10}$ths per cent.

Ystalyfera cold blast—average deflection,	lbs.	1.916
Deflection of cold blast iron from Mr. Fairbairn's table,		1.612
Difference in favor of Ystalyfera iron,		.304

equal to $18\frac{8}{10}$ths per cent.

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Ystalyfera cold blast iron, in respect to its resisting impact, general average of five feet bars.	lbs.	1235
Hot blast iron from Mr. Fairbairn's table,		690
Difference in favor of Ystalyfera iron,	lbs.	545

—equal to 79 per cent.

Ystalyfera cold blast iron, in respect to its capacity to resist impact,		1235
Cold blast iron from Mr. Fairbairn's table,		734
Difference in favor of Ystalyfera iron,	lbs.	501

—equal to $68\frac{2}{10}$ths per cent.

From these and the former comparative experiments, it is abundantly evident that the pig iron, now making with cold blast and anthracite, at the Ystalyfera Iron Works, greatly exceeds, in strength, and deflective powers, and capacity to resist impact, any iron at this time manufactured in the United Kingdom. It now only remains for me to mention a property peculiar to the iron, which was noticed at the time I made the trial experiments at Yniscedwyn, four years ago, but which has been more fully developed in those recently made at Ystalyfera. The property referred to is one of great springiness, or elasticity, which communicates a tendency to the bar, in deflecting and breaking, to resume its rectangular form. Bars that had obtained a permanent set of 2-10ths, when afterwards broken, presented but a slight deviation from a right line, and in no case did the acquired curvature exceed one-fourth of a tenth. It was also remarked that most of the fractures, in breaking, presented a regularity of grain throughout, resembling the structure of unhardened steel.

Coleford, Nov. 18. DAVID MUSHET.

Railway Mag.

Experiments on the Explosive Effects of certain Mixtures of Gunpowder and Air. By CHARLES THORNTON COATHUPE, Esq.

Sir,—The following experiments, illustrating certain effects produced by the explosion of gunpowder, may be interesting to some of your readers. Being exceedingly fond of rifle-shooting, it so happened, during a morning's practice, that the ball became so fixed in the barrel, at a short distance above the charge of powder, that I could not, with the implements then present, force it "home." I had often heard of guns bursting from similar incidents, but, having duly surveyed the substance of the metal around the bore of the barrel, I thought—*well, this cannot burst.*

The rifle was very small, having two grooves in the barrel, and carrying a ball weighing the $\frac{1}{38}$th of a lb. avoirdupois. The charge of powder was 20 grs. of the best quality, ("extra canister;") the target was a wrought iron plate, $\frac{1}{4}$ inch thick; the distance was 100 yards, and the usual effect upon the target was the slightest possible

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indentation of the surface upon which the ball impinged, (the ball being smashed to atoms.)

On this occasion, however, the ball all but perforated the entire substance of the plate. The indentation was deep and conical, bursting open the opposite surface of the plate.

It immediately occurred to me that this unexpected result might be turned to advantage, by making barrels so strong, that, instead of the thus increased force of an ordinary charge of powder being spent in bursting the tube in which it might happen to be exploded, it might be expended in propelling its ball. I therefore had a small cannon manufactured of twisted wrought iron, and bored from the solid mass, leaving the substance of iron around the bore so thick that it could not be injured by any method of exploding gunpowder within it. Its bore was 11 inches long, and its calibre suited a ball weighing $\frac{1}{23}$d of a lb. avoirdupois. It was charged with 56 grs. of Curtis and Harvey's "canister powder," and it was fired at a target composed of eight planks of half-inch elm board, under the following circumstances, each experiment being repeated three times. The distance was ten yards.

			Ball through	and into
1st	average,	powder and ball alone,	5 planks	6th
2d	do.	with air equal half bulk of the powder,	5 "	6th
3d	do.	with air equal whole bulk of the powder,	6 "	7th
4th	do.	with air equal one and a half bulk of the powder,	5 "	
5th	do.	with air equal two bulks of powder,	5 "	(barely.)

It may be asked how I ascertained that the bulks of air included above the powder were precisely such as I have reported them to have been.

In the first place, I prepared some cylinders of cartridge paper, which exactly fitted the bore of the cannon, and, having ascertained the requisite length of one of these cylinders to contain just 56 grs. weight of powder, I divided each cylinder, as it revolved in a lathe upon a wooden mandril, into lengths proportioned to the volumes of air they were intended to contain. Over one extremity of each cylinder thus cut and regulated, I pasted a slip of very thin muslin. In loading, the powder was inserted through a brass tube, the gun being held perpendicularly. The paper cylinder was then slid down upon the powder with the closed end downwards. Above the paper cylinder a piece of mill-board, cut with a gun-punch of the precise diameter of the bore, was inserted, and above this the ball was placed, and retained in its situation by means of a circular piece of thick card. Previous to each discharge, the gun-carriage was fixed firmly to the ground by an iron rod, that any errors from the recoil of the gun might be obviated.

Although these experiments are of too rough a nature to give the exact effect of each discharge, they still afford an ample illustration of the limits within which air can be advantageously combined with gunpowder for practical purposes. It appears that about equal bulks

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of air and of powder produce the best results; and this relative proportion of air seems to increase the explosive force of gunpowder by about the one-fifth of that which would have been obtained had the air been altogether excluded. Hence 20 per cent. of gunpowder may be saved, the effects remaining constant; or, the usual charges of powder being retained, their effects may be increased nearly in the ratio mentioned above. This principle may be economically adopted, either for propelling balls, or for blasting rocks. Mech. Mag.

On a Re-arrangement of the Molecules of a Body after Solidification. By ROBERT WARINGTON, Esq.

Having occasion, lately, to prepare some alloys of lead for the purpose of lecture-illustration, I was much surprised at an alteration taking place in the arrangement of the particles of one of these alloys, as shown by the appearance of the surfaces of fracture, after the metal had assumed the solid form. The alloy experimented on was that known as Newton's fusible metal, composed of eight parts of bismuth, five of lead, and three of tin. On pouring this alloy, in the melted state, on a marble slab, and breaking it as soon as solid, and when it may be readily handled, the exposed surfaces were found to exhibit a bright, smooth, or conchoidal, metallic appearance, of a tin white lustre; and the act of disjunction at one part will, frequently, cause the whole to fly into a number of fragments, analogous to the breaking a piece of unannealed glass.

The metal, after this, becomes so hot as to burn the fingers if taken up; and when this evolution of heat has ceased, the alloy will be found to have entirely altered its characters, having lost its extreme brittleness, requiring to be bent to and fro several times before it will break, and presenting, on fracture, a fine granular, or crystaline, surface, of a dark color, and dull, earthy aspect. Similar phenomena accompany the casting of the fusible alloy of V. Rose, composed of two parts of bismuth, one of lead, and one of tin.

The fact of the evolution of heat from the alloy of Newton, and its cause, are thus noticed by Berzelius, in his *Traité de Chimie:*—"If this alloy is plunged into cold water, and quickly withdrawn and taken in the hand, it becomes sufficiently hot, after a few moments, to burn the fingers. The cause of this phenomenon is, that, during the solidification and crystalization of the *internal parts*, the latent heat of these is set free, and communicates itself to the surface before the fixing and cooling." The alteration in the internal arrangement of the particles, as proved by the surfaces of fracture, is not, however, noticed, and the explanation is defective, as it supposes the interior not to have assumed the solid state until the evolution of the heat occurs. If such were the case, it would be seen on breaking it in the first instance. The phenomena can only be accounted for by admitting a certain degree of mobility among the particles, and that a second molecular arrangement takes place after the metal has solidified.

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This may arise from their not having assumed, in the first state, that direction in which their cohesion was the strongest.

That a very marked and extraordinary alteration in the characters and properties of various substances, arises entirely from this change in the position of their component particles, effected either by the communication or abstraction of heat after solidification, there can be no doubt. And these changes are applied to many very important purposes in the arts and manufactures—such as the hardening and tempering of steel, the rolling of commercial zinc, and rendering that metal permanently malleable, the annealing of glass, and a variety of other uses, particularly in crystalization, which might be adduced.

The following experiments were made to ascertain to what extent the emission of latent heat takes place. The melted alloy was poured, in a perfectly fluid state, on the bulb of a thermometer, placed in a small platinum crucible, having a capacity equal to about 70 grain measures of water, and standing in a vessel of cold water, or mercury. The thermometer, surrounded by the solidified metal and crucible, was removed from the cooling medium before it had reached its stationary point, and the greatest decrease of temperature noted. The heat then rose rapidly again, and the maximum effect was registered. The fusing point of the alloy was 202° Fahrenheit, and the following results were obtained:

Exper.			Fahr.		Fahr.	Diff. Fahr.
1	thermometer	fell to	97°	and then rose to	157°	60°
2	"	"	94	"	149	55
3	"	"	90	"	150	60
4	"	"	87	"	147	60
5	"	"	104	"	156	52
6	"	"	97	"	148	51
7	"	"	92	"	152	60
8	"	"	104	"	155	51

So that, in four out of the eight trials, a difference of 60° Fahrenheit was rendered apparent.

In a platinum crucible of larger size the effects were not so marked, 34° Fahrenheit being the greatest difference obtained; this, of course, would arise from the greater bulk of the melted metal not exposing, comparatively, so large a surface to the cooling medium.

Edinb. N. Philos. Jour.

Stone Boring Machine.

Mr. Carnegie presented one of Hunter's stone boring machines to the Institution of Civil Engineers, and explained its action to the meeting.

The machine is composed of two parallel bars of steel, supporting a traversing carriage, through the centre of which passes a spiral auger attached to a screwed bar; this bar fits into a female screw clamp above the carriage, and on the upper end is a winch with four handles.

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When the instrument is in use, it is fixed by two cramps upon the stone to be pierced, and the auger, being made to revolve by means of the winch, scoops out, at each revolution, as great a depth of stone as is equal to the distance which the screw descends; the chips, ascending through the spiral channel of the auger, are thrown off at the top. The peculiar shape of the point of the auger prevents its being abraded, as it operates by chipping the stone, and not by grinding it away. This, with the means of forcing it down by the screw, is the chief novelty of the machine. It has been extensively used at the works of the new harbor of Arbroath, by Mr. Leslie, who speaks of it in the following terms:

"Mr. Hunter's boring machine has been advantageously employed for above a year, in boring trenail holes in the stones used at the new harbor of Arbroath. The holes are 1¾ inch diameter, and from nine inches to two feet in depth; the aggregate of the holes already bored amounts to upwards of 30,000 linear feet. The machine may be adapted for boring holes of any dimensions. It does the work considerably cheaper than the 'jumper,' and much more correctly, as it makes the holes perfectly straight, cylindrical, and equal throughout, instead of the irregular form made by the common jumper. This machine is very well adapted for boring railway blocks, and has been much used in this quarter for that purpose. I consider it to be more especially valuable from the facility which it affords of boring and trenailing down the stones used in sea buildings, in any exposed situation; as I have found that trenailing is a great security to such building while in progress, when the upper courses are much exposed, and liable to be washed off, unless they be held down by other means than their own absolute weight.

"The expense of boring the old red sand-stone rock, here, is about three halfpence per linear foot."

Mech. Mag.

Sugar from Maize, &c.

Paris Academy of Sciences, Sept. 12.—A report was read on the production of sugar from maize.—A paper by M. Huan, on the means of preventing accidents on railways by the breaking of an axletree. The invention consists of such a modification of the wheel of the locomotive, that if the axle should break, the wheel itself becomes an axle, and prevents further accident.—M. Arago, in allusion to the opinion expressed by several persons as to the electricity of whirlwinds, mentioned to the Academy some observations made by M. Hortola on a storm, on the 24th ult., in the department of the Aude. This gentleman relates that, on the occasion referred to, the iron bars of windows, the gutters of sheet iron, the plates of insurance companies, and other metallic objects, were carried away by the whirlwind, thus indicating the presence of electricity.

Lond. Athenæum.

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Photography. *By* Sir John Herschel.

The preparation of the chrysotype paper is as follows: dissolve 100 grains of crystalized ammonio-citrate of iron in 900 grains of water, and wash over with a soft brush, with this solution, any thin, smooth, even-textured paper. Dry it, and it is ready for use.

On this paper a photographic image is very readily impressed, but it is extremely faint, and, in many cases, quite invisible. To bring out the dormant picture, it must be washed over with a solution of gold in nitro-muriatic acid, exactly neutralized with soda, and so dilute as to be not darker in color than sherry wine. Immediately the picture appears, but not at first of its full intensity, which requires about a minute, or a minute and a half, to attain, (though, indeed, it continues slowly to darken for a much longer time, but with a loss of distinctness.) When satisfied with the effect, it must be rinsed well two or three times in water, (renewing the water,) and dried.

In this state it is half fixed. To fix it completely, pass over it a weak solution of hydriodate of potash, let it rest a minute or two, (especially if the lights are much discolored by this wash,) then throw it into pure water till all such discoloration is removed. Dry it, and it is thenceforward unchangeable in the strongest lights, and (apparently) by all other agents which do not destroy the paper.

The other process is as follows: mix together equal parts of the solution of the above-named salt, and of a saturated solution of, not the ferrosesquicyanate of potash, (as stated in the Athenæum,) but the common yellow ferrocyanate, or, as it is called, prussiate of potash. The result is a very black ink, which, washed over paper, gives it a deep violet-purple color, and is remarkably sensitive to light—whitening rapidly, and giving positive pictures—the only defect of which (and it is a fatal one for use) is their want of durability, as they fade with darkness in a few hours. And, what is very singular, the *same paper* is again and again susceptible of receiving another and another picture, which die away in like manner, without any possibility, so far as I have yet discovered, of arresting them. Ibid.

English Patents.

Specification of the Patent granted to William Henry Fox Talbot, *of the County of Wilts, for Improvements in Coating, or Covering, Metals with other Metals, and in Coloring Metallic Surfaces.* Sealed December 9, 1841. Enrolled June 9, 1842.

To all to whom these presents shall come, &c.—The first part of my invention consists of adding gallic acid to the metallic solution intended to be precipitated. I take any convenient solution of silver, gold, or platina, and I add to each of them a solution of gallic acid in

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water, ether, or alcohol, which latter I consider preferable. Into any one of these mixtures I then immerse a clean bright plate of metal, until it becomes coated (as the case may be) with silver, gold, or platina. I find it best, in general, to begin with a weak, or dilute, solution, and afterwards to use a stronger one. The gallic acid need not be pure; but cheaper liquids, containing a considerable portion of it, or of an analogous vegetable substance, may be used instead of the pure acid. With respect to this part of my invention, I claim the use of gallic acid, or liquids containing it, or an analogous vegetable substance, for facilitating the precipitation of metals upon other metallic surfaces, and coating them therewith. The next part of my invention is a method of silvering metallic surfaces. For this purpose I dissolve freshly precipitated chloride of silver in hypo-sulphate of soda, or any other liquid hypo-sulphate, which I believe to be the only class of bodies, hitherto discovered, which have the property of dissolving chloride of silver freely and abundantly. Into this solution I then immerse a clean bright plate of metal, and it is very rapidly coated with a bright silver coating. In order to obtain thicker coats of metal, I employ a galvanic battery in the way now well known, using one of the liquids described in the first and second parts of this specification, and employing for one of the poles, or electrodes, a piece of metal of the same kind as that which is intended to be precipitated. With respect to this part of my invention, I claim the use of hypo-sulphate of soda, or other liquid hypo-sulphate, for the silvering of metals, and the employing a galvanic battery for obtaining thicker deposits of silver, gold, or platina; but I claim this only when used in conjunction with one of the liquids above described. The metals which may be coated with other metals, by the processes above described, are brass, copper, German silver, and also (though less effectually) iron and steel.

The next part of my invention is a method of ornamenting surfaces of brass, or copper, by first gilding them partially according to some pattern, and then washing them over with a solution of chloride of platina, which has no action on the gilt parts, but gives a dead black appearance to the rest of the surface, thus enhancing the brilliancy of the parts which are gilt.

The last part of my invention is a method of coloring polished surfaces of copper, by exposing them to the vapor of sulphuretted hydrogen, or of any of the liquid hydro-sulphurets, or to the vapors of sulphur, iodine, bromine, or chlorine, or by dipping the metal into liquids containing them; but I prefer to use the hydro-sulphurets as above mentioned. By this means, very brilliant colors are obtained on the copper, and, by partially protecting the surface of the metal, according to any determinate or ornamental pattern, very pleasing effects are produced, exhibiting great contrast of colors in a little space. As it is easy to render the copper nearly white by the method above described, I employ it for obtaining metallic specula, or mirrors, as follows. I take an electrotype cast in copper from a polished plane, or spherical metallic surface, which cast has nearly the same degree

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of polish as the original, and I then expose it to the action of vapors, as above described, until it is sufficiently whitened, which is effected without injuring the polish. As the surface of the speculum thus obtained is already combined chemically with sulphur, or one of the other bases, or substances, above mentioned, it is consequently less liable to tarnish, or oxydate, subsequently, by any exposure to the atmosphere. With respect to this last part of my invention, I claim the coloring of copper surfaces by exposing them to the chemical action of the above-named substances. Rep. Pat. Inv.

Specification of a Patent granted to Edward Brown, *of the county of Glamorgan, for a new Principle, applied to the Roasting and Refining of Copper.* Sealed 22d June, 1839. Enrolled December, 1839.

The patentee commences his specification by observing, that the usual process which the ore is required to undergo, in order that the copper may be separated from the impurities with which it is combined in the mineral state, are six in number, viz.: first, calcining the ore; secondly, smelting the calcined ore; thirdly, calcining the coarse metal; fourthly, smelting the calcined metal; fifthly, roasting the metal; and, sixthly, refining and toughening it.

The invention relates to the last two processes, and comes into operation when the coarse, or blistered, copper is in a state of fusion in the reverberatory furnace, covered by the slag, or scoria, made in the process of roasting the metal.

Upon the fused metal a flux is thrown, composed of equal parts of quick-lime and anthracite, or other, coal; or of equal parts of lime and wood charcoal, finely powdered. This is stirred in, by means of an iron rable, until the scoria, which was previously of a red color, is changed into a black, frothy mass; it is then skimmed off the surface of the metal, which is afterwards tapped into the sand-bed. The quantity of flux required is from half a bushel to a bushel for each charge of metal.

The blistered copper is now put into the refining furnace, and further roasted and melted until it becomes pure, and ready to undergo the improved toughening process, which consists in covering the surface of the metal with a mixture of equal parts of finely-sifted lime and pulverized wood charcoal, or of lime and saw-dust, or lime and anthracite coal, coarsely powdered, (polling the metal as usual;) the quantity required, at the commencement of the polling, being about three Winchester bushels; an addition is afterwards made, if necessary, in order to preserve the surface of the metal from exposure to the air that passes through the furnace. By this process, the remaining portion of sulphur, and other impurities, which are inseparable from the copper by the ordinary method, are effectually removed, and the metal becomes highly ductile and malleable.

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The patentee claims the application, or use, of any portion of lime, in combination with any other matters, or substances, whatsoever, in roasting, or in refining, copper ores. Lond. Jour. Arts & Sci.

Specification of a Patent granted to Thomas William Booker, *of Melin Griffith's Works, near Cardiff, for Improvements in the Manufacture of Iron.* Sealed 22d February, 1841. Enrolled August, 1841.

These improvements consist in accelerating the operation of converting cast-iron into malleable iron. It consists in running off the metal, in a fluid state, after the refining process is complete, from the refinery into the puddling furnace, through a passage that connects the two furnaces. The metal is then puddled, and divided into lumps, or balls, as usual, in readiness for passing between the rolling cylinders, or other apparatus used for compressing, or forging, the iron. Ibid.

Meteorological Observations for November, 1842.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	38°	59°	30.24	30.15	W.	Moderate		Hazy.	Hazy.
⊗	2	45	56	30.15	30.15	E.	do		Hazy.	Hazy.
	3	36	48	29.80	29.80	NE.	do		Clear.	Clear.
	4	31	48	29.78	29.70	W.	do		Clear.	Clear.
	5	36	55	29.70	30.65	W.	Calm		Clear.	Hazy.
	6	41	67	29.95	29.96	W.	do		Clear.	Hazy.
	7	44	63	29.86	29.80	S.	do		Par. cloudy.	Hazy.
	8	49	49	29.35	29.30	NE.	Moderate	1.60	Rain.	Rain.
☾	9	47	57	29.55	29.55	W.	do	.04	Cloudy.	Rain.
	10	36	47	29.80	29.80	W.	Brisk		Cloudy.	Flying clouds.
	11	36	48	30.00	30.00	W.	do		Clear.	Par. cloudy.
	12	38	46	30.10	30.10	E. S.	do	.15	Rain.	Cloudy.
	13	36	46	29.98	30.00	SW.	do		Clear.	Clear.
	14	35	44	29.95	29.95	NE.	Moderate		Flying clouds.	Cloudy.
	15	34	44	29.90	29.90	W.	do		Clear.	Clear.
	16	34	49	29.80	29.80	NE.	do	.03	Snow.	Cloudy.
☉	17	38	46	29.85	29.75	E. SE.	do	.77	Cloudy.	Rain.
	18	47	37	29.30	29.35	W.	Blustering		Cloudy.	Clear.
	19	25	38	29.70	29.80	W.	do		Clear.	Clear.
	20	24	35	30.10	30.10	W.	Moderate		Clear.	Clear.
	21	24	36	30.15	30.15	W.	do		Clear.	Cloudy.
	22	21	35	30.15	30.14	W.	do		Par. cloudy.	Par. cloudy.
	23	23	38	30.14	30.10	W.	Calm	.08	Clear.	Rain.
	24	23	42	29.75	29.80	W.	Brisk		Cloudy.	Clear.
☽	25	25	39	30.10	30.10	W. SW.	Moderate		Clear.	Clear.
	26	25	39	30.11	30.14	W.	do		Clear.	Clear.
	27	30	28	29.63	29.55	W.	Brisk		Cloudy.	Clear.
	28	18	28	30.10	30.10	W.	Moderate		Clear.	Cloudy.
	29	16	30	30.25	30.30	W.	do		Clear.	Clear
	30	23	28	30.15	29.74	E.	do	.80	Cloudy.	Cloudy—snow.
		32.60	44.17	29.91	29.93			3.47		

Thermometer.		Barometer.	
Maximum 67 on 6th. Minimum 16 on 29th.	Mean 38.385	Max. 30.65 on 5th. Min. 29.30 on 8th & 18th.	Mean 29.92

JOURNAL

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Civil Engineering.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from* "*No.* 13 *du Mémorial de l'Officier du Génie,*" *by Captain* JOHN SANDERS, *Corps of Engineers.*

[CONTINUED FROM PAGE 79.]

Formulas and Tables relative to any kind of Earth or Masonry.

25. The foregoing considerations, and the utility, in practice, of having exact and simple means of solution, have induced me to extend the preceding calculations to the principal cases of application, especially to those which refer to the least and greatest thicknesses of masonry, or to intermediate thicknesses with reference to those of the preceding case.

In consulting, on this subject, the results of experiments, given by various authors upon the densities of earth and masonry of different qualities, we find that the ratio of $p:p'$ of these densities, which rarely reaches unity, is, on the contrary, seldom ever less than $\frac{3}{5}$, or 0.6. If, on the other hand, we refer to the results of observations relative to the slope which loose earth naturally takes, we find the angle α of the slope with the vertical, is between 70°, which is that of fine and dry sand, and 35°, which corresponds to the stiffest and densest earth; in other terms, the coefficient $f = \cot \alpha$, of friction, which can be as high as 1.4 in the latter case, is never less than 0.6 in the former. It is, then, between these extremes that the most ordinary cases in application arise, and for which we propose to calculate a table of the thicknesses of vertical revetments. But, before presenting these results, I

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shall briefly indicate the analytical expressions, and methods which serve to establish them, as it might be useful to make them known to those who would be disposed to complete and extend the calculations for other values of the principal given quantities.

26. Still preserving the notations and terms heretofore adopted, and, more especially, continuing to take $\delta = 1.912$, $n = 0$, and the angle $\theta = \alpha$, an hypothesis favorable to the stability, we shall have, (3) since f tang. $\theta =$ cot α tang. $\theta = 1$,

$$P = \tfrac{1}{2}p(\sqrt{1+f^2} - \sqrt{u^2+f^2})^2(H+h)^2$$

$$M = \tfrac{1}{6}p\left[1 + 2f^2 + 3u^2 + \frac{2u^3}{f^2} - \frac{2}{f^2}\sqrt{1+f^2}(u^2+f^2)^{\frac{3}{2}}\right]$$

$$(H+h)^3$$

the value of u being furnished by the expression (fig. 1)

$$u = \frac{GH}{BG} = \frac{h'}{H+h} = \frac{a-f(x-m)}{a+1} = 1 - \frac{1+f(x-m)}{a+1}$$

in which

$$a = \frac{h}{H}, x = \frac{e}{H}, \text{ and } m = \frac{b}{H}.$$

We now deduce, in proceeding as heretofore, in number 15, [and in adding $+f^2u^6 - f^2u^6$ to the numerator of the fraction,] for the length of the arm of the lever of the pressure P,

$$\frac{M}{P} = \tfrac{1}{3}(H + h - h')(1 + U),$$

in supposing:

$$U = \frac{f^2u + (2+f^2)u^3 - 2u^2\sqrt{1+f^2}\sqrt{u^2+f^2}}{f^2(1-u)(1+u)^2} =$$

$$= \frac{f^2(1-u)u}{f^2 + (2+f^2)u^2 + 2u\sqrt{1+f^2}\sqrt{u^2+f^2}}$$

and (7), in the place of the equation of equilibrium (n), of number 19,

$$(s)\begin{cases} x^2 + \frac{2}{3}\frac{p}{p'}f(x-m)^2(x+\frac{1}{2}m) \\ = \frac{\delta p}{3p'f^2}\left[f^2 + 2f^4 + 3f^2u^2 + 2u^3 - 2\sqrt{1+f^2}(u^2+f^2)^{\frac{3}{2}}\right](a+1)^3 \\ = \frac{\delta p}{3p'}(\sqrt{1+f^2} - \sqrt{u^2+f^2})^2(a+1)^2[1+f(x-m)](1+U). \end{cases}$$

27. In the case of fig. 2, or of CG < CH, that is to say, $a < f(x -$

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m) and u negative, this equation will be replaced by the following, (9):

$$(t) \quad x = \sqrt{p\,\frac{\delta f^2(\sqrt{1+f^2}-f)^2(a+1)^3+(a+fm)^3-f^3m^3}{3f^2(p'+ap)}}$$

δ being always equal to 1.912, and $\sqrt{1+f^2}-f$ representing here the value of tang. $\frac{1}{2}\alpha$ (6).

28. When the width of the berm is equal to the thickness of the wall, or $m = x$, we shall have likewise (5) and (8):

$$u = \frac{a}{a+1}, \text{ and}$$

$$x = \sqrt{\frac{\delta p}{3p'}\left[1+2f^2+3u^2+\frac{2u^3}{f^2}-\frac{2}{f^2}\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}\right](a+1)^{\frac{3}{2}}}$$

or, by the transformation explained in a following number, (30)

$$(u) \quad x = \sqrt{\frac{\delta p}{3p'}\,\frac{4u^3+f^2(1+3u)}{f^2+2f^4+3f^2u^2+2u^3-2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}}}$$

a formula which answers for all values of u, that is to say, from $a = 0$, to a equal to infinity.

29. In order to prepare a table of the values of x, relative to a series of equidistant values of a, and to a certain hypothesis made upon simultaneous values of p, p', f, and m, we shall commence by using formula (t), which gives x immediately, and will be applicable, as has been said, as long as a shall be less than $f(x-m)$; but, as soon as the reverse occurs, it will be necessary to have recourse to equation (s), and to continue on with it indefinitely for the successively increasing values of a.

In principle, we might content ourselves with solving this question by the method pointed out in the 16th and following numbers; and to that end we have drawn up an auxiliary table of the values of the function U, which table will be given hereafter in the second section; but, although the second member of this same equation may be easily calculated by logarithms, nevertheless, this method of solution is so laborious, that it soon became necessary to renounce it in adopting a more expeditious one.

30. Dividing the equation (s) by $\frac{2}{3}\frac{p}{p'}[1+f(x-m)]^3$, or

$\frac{2}{3}\frac{p}{p'}(a+1)^3(1-u)^3$, since (26)

$$a+1 = \frac{1+f(x-m)}{1-u}$$

multiplying afterwards both terms of the fraction

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$$\frac{f^2+2f^4+3f^2u^2+2u^3-2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}}{f^2(1-u)^3}$$

which will remain as a factor of the second member of the equation, by the sum of all the terms of the numerator taken positively, we shall give to this fraction the form:

$$\frac{4u^3+f^2(1+3u)}{f^2+2f^4+3f^2u^2+2u^3+2\sqrt{1+f^2}\,(u^2+f^2)^{\frac{3}{2}}}=\mathrm{V}$$

under which form it will cease to take indeterminate values for $u=1$, or $a=\infty$, and will thus serve to give the limits of the values of x, or of the thicknesses of demi-revetments (21). In fine, supposing, in order to abridge the substitutions,

$$fx=x', \qquad fm=m',$$

the equation (s) will finally become:

$$(s') \quad \frac{\left(\frac{3}{2}\frac{p'}{p}-\frac{3}{2}m'+x'\right)x'^2+\frac{1}{2}m'^3}{(1-m'+x')^3}=\tfrac{1}{2}\,\delta f^2\,\mathrm{V}=0.956f^2\,\mathrm{V},$$

and will permit our easily proceeding in the calculation of each of the series of the values of x, corresponding to the different values of a, and to the values arbitrarily assigned to the constants f, m, p, and p'.

31. Having calculated and drawn up, in the first place, an auxiliary table of the values of $\frac{1}{2}\,\delta f^2\,\mathrm{V}$, relative to a certain value of f, from $u=0$ to $u=1$, increasing by tenths, which will be near enough, we shall calculate from it another of the values of the first member, taking care previously to substitute for $\frac{p'}{p}$ and $m'=fm$, the numbers relative to each hypothesis, and attributing afterwards to x' values increasing by half a tenth, from that which gives a result immediately below

$$0.956\frac{f^2}{(\sqrt{\mathrm{H}+f^2}+f)^2},$$ unto that which gives one immediately above

$$0.956\frac{f^2}{(1+f^2)}$$

values which $0.956f^2\mathrm{V}$, the second member of the equation (s') respectively takes for $u=0$ and $u=1$, and which we may be sure not to go beyond, in commencing the substitutions by $x'=0.6f$, and afterwards in continuing them above and below this quantity.

That done, we shall seek in the second table, thus calculated, the consecutive numbers between which each of those of the first is found comprised, and, by the division into proportional parts of the difference between the corresponding values of x or x', we shall then find, to a degree of approximation exact enough for the object in view, as many values of x corresponding to those of u; whence we shall afterwards deduce those of a, by the relation (26)

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$$1+a=\frac{1+f(x-m)}{1-u}=\frac{1+x'-m'}{1-u}$$

There will still remain for us to prepare a regular table of the values of x relative to the different successive values of a which we wish to consider; this can be done by known methods of interpolation, or in constructing curves having for horizontal abscissas the values of a thus found, and for vertical ordinates the corresponding values of x.

32. Such in fact is the process which I have followed in calculating the numbers of the following table; but as the curves in question form infinite or hyperbolical branches, having for assymptotes, horizontals situated above the axis of abscissas or of a, at distances equal to the respective limits of x, relative to $u=1$ or a equal to infinity, we can, by this purely geometrical proceeding, obtain, with the desirable approximation, only the first numbers of the regular table just spoken of, and we are obliged to calculate the following numbers by a method of interpolation, which consists in taking for an approximate representation of the hyperbolical branches, an equation of the form

$$x=x_{,}\frac{k}{g+a}$$

in which $x_{,}$ is that limit of x relative to $u=1$, or $a=\infty$, and which is furnished (30 and 31) by the equation of the 3rd degree:

$$f^2x_{,}^2\left(\frac{3p'}{2p}-\frac{3}{2}fm+fx_{,}\right)+\tfrac{1}{2}f^3m^3=0.956\frac{f^2}{(1+f^2)}\left[1+f(x_{,}-m)\right]^3;$$

the other two constants, k and g being determined by simultaneous values of x and a, suitably chosen among those which have been found in the first place by means of equation, (s') that is to say, among the greatest of them.

It is thus by example in the particular case of earth and masonry of mean densities, and for $m=0$, we find the formula:

$$x=1.243-\frac{1.5443}{1.43+a}$$

which gives to less than $\frac{1}{93}$ the values of x corresponding to values of a, comprised between $a=1$, and even between $a=0.6$ and a equal to infinity. Moreover, we can easily shun this difficulty by adopting the following course, which is very exact, and purely geometrical.

33. After having calculated, as has been explained in the first place, the values of x, relative to $u=0$, $u=0.1$, $u=0.2$, &c., &c., we can construct a curve, having the latter for abscissas and the other for ordinates; there will then remain to be found for each of the values given to a, the corresponding value of x, by means of the relation

$$u=\frac{a-f(x-m)}{a+1},$$

which being linear in x and u, represents a right line, whose intersection with the curve will have for an ordinate the sought value of x. The construction of this right line will be effected very simply, in observing that it passes, whatever may be the particular value of a, by

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the point whose co-ordinates are $u=1$, and $x=m-\frac{1}{f}$, a quantity essentially negative, and which therefore is to be carried below the axis of abscissas, or of u; there will only then remain a second point of the line to be constructed, which will be variable only with a, and of which by example the constant ordinate will be taken equal to $m+\frac{1}{f}$, corresponding to an absciss $u=\frac{a-1}{a+1}$, which it will be necessary each time to apply upon the horizontal determined by this same ordinate.

34. That which distinguishes this last method, is that the curves in u and x, which are used, have a form differing very little in general from the arc of a circle, so that for example, it will be sufficient to construct only three points of it corresponding to the values of 0, 0.5, and 1.0 of u, to be able to find immediately, and with a sufficient degree of approximation, the value of x answering to any given value of a. But this remark, which can serve in abridging the calculations for establishing a table, would be of no use in finding a particular value of x, since it would require, for three distinct values of u, the solution of equation (s') which, although reduced to the third degree, is not of much easier solution.

This same remark can, moreover, be applied to the foregoing formula (32) of interpolations, relative to the greatest values of x and a, observing that it contains three parameters, $x_{,}$, k, and g, the general relation of which with the constants f', m, p, and p', does not appear to be easily discovered, even in limiting the degree of approximation to that which practical applications call for—at least our researches on this subject have been fruitless.

We shall soon see that it will be otherwise in the case of small values of a, or of light loads; but it is better, first, to present the result of the numerical calculations which we have made, and which are given in the following table:

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General Table

Of Thicknesses (in fractions of the heights) of Vertical Revetments with superincumbent loads of earth, calculated on the hypotheses of rotation, and of their having a stability equivalent to that of the model revetment of Vauban.

Value of $a=\frac{h}{H}$	Values of $x=\frac{e}{H}$, for $p'=p$, $f=0.6$, the berm being		Values of x or $\frac{e}{H}$, for $p'=p$, $f=1.4$, the berm being		Values of x or $\frac{e}{H}$, for $p'=1.5p, f=1$ the berm being			Values of x or $\frac{e}{H}$ for $p'=\frac{4}{3}p$ $f=0.6$ the berm being		Values of x or $\frac{e}{H}$ for $p'=\frac{4}{3}p$ $f=1.4$ the berm being	
	Zero	equal to 0.2 H	Zero	equal to 0.2 H	Zero	equal to 0.2 H	equal to e.	Zero	equal to 0.2 H	Zero	equal to 0.2 H
0.0	0.452	0.452	0.258	0.258	0.270	0.270	0.270	0.350	0.350	0.198	0.198
0.1	0.498	0.507	0.282	0.290	0.303	0.306	0.303	0.393	0.398	0.222	0.229
0.2	0.548	0.563	0.309	0.326	0.336	0.342	0.326	0.439	0.445	0.249	0.262
0.3	0.604	0.618	0.338	0.361	0.368	0.375	0.343	0.485	0.489	0.274	0.288
0.4	0.665	0.670	0.369	0.394	0.399	0.405	0.357	0.532	0.522	0.303	0.299
0.5	0.726	0.717	0.402	0.423	0.436	0.431	0.368	0.579	0.549	0.332	0.314
0.6	0.778	0.754	0.436	0.450	0.477	0.457	0.377	0.617	0.572	0.360	0.328
0.7	0.824	0.790	0.472	0.476	0.512	0.481	0.385	0.646	0.593	0.387	0.343
0.8	0.867	0.820	0.510	0.501	0.544	0.504	0.391	0.668	0.610	0.413	0.357
0.9	0.903	0.848	0.541	0.524	0.575	0.523	0.398	0.690	0.624	0.437	0.371
1.0	0.930	.873	0.571	0.546	0.605	0.540	0.405	0.707	0.636	0.457	0.384
1.2	0.983	0.916	.632	0.586	0.654	0.574	0.411	0.737	0.655	0.498	0.410
1.4	1.023	.945	0.684	0.624	0.696	0.602	0.416	0.762	0.672	0.537	0.428
1.6	1.056	0.970	.730	0.658	.734	0.622	0.420	0.780	0.685	0.566	0.445
1.8	1.084	0.990	0.772	0.690	0.769	0.640	0.423	0.797	0.697	0.594	0.46.
2.0	1.107	1.004	0.812	0.714	0.795	0.655	0.425	0.811	0.705	0.622	0.475
2.5	1.151	1.037	0.902	0.778	0.848	0.690	0.431	0.833	0.722	0.680	0.506
3.0	1.180	1.060	0.981	0.835	0 892	0.717	0.435	0.852	0.731	0.726	0.531
3.5	1.203	1.074	1.047	0.883	0.928	0.738	0.438	0.862	0.737	0.765	0.551
4.0	1.222	1.084	1.105	0.926	0.957	0.755	0.442	0.872	0 742	0.800	0.568
4.5	1.237	1.093	1.158	0.962	0.981	0.768	0.444	0.878	0.747	0.833	0.583
5.0	1.247	1.101	1.206	0.994	1.002	0.779	0.445	0.883	0.751	0.862	0.596
5.5	1.254	1.109	1.250	1.021	1.019	0.788	0.447	0.886	0.756	0.885	0.607
6.0	1.259	1.116	1.290	1.047	1.034	0.796	0.448	0.891	0.759	0.903	0.617
7.0	1.269	1.112	1.357	1.087	1.059	0.811	0.449	0.898	0.764	0.941	0.633
8.0	1.276	1.128	1.415	1.121	1.079	0.822	0.451	0.903	0.768	0.968	0.646
9.0	1.280	1.133	1.465	1.153	1.095	0.830	0.452	0.906	0.770	0.992	0.657
10.0	1.283	1.137	1.508	1.182	1.109	0.839	0.452	0.909	0.771	1.013	0.667
15.0	1.298	1.150	1.662	1.271	1.149	0.864	0.455	0.917	0.777	1.088	0.696
20.0	1.309	1.156	1.757	1.327	1.171	0.878	0.456	0.922	0.780	1.129	0.712
25.0	1.312	1.160	1.821	1.363	1.185	0.887	0.457	0.924	0.782	1.146	0.723
30.0	1.316	1.162	1.866	1.389	1.194	0.894	0.458	0.926	0.783	.174	0.730
Infin't	1.337	1.175	2.144	1.541	1.243	0.927	0.461	0.934	0.789	1.279	0.769

Consequences and Use of this Table.

35. This table, established upon the same bases as that of No. 20, does not call for any particular explanation, and leads to analogous

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consequences relative to the finite and rather small limit of the values of the proportional thicknesses x of the wall; to the variable influence of the width of the berm, &c., &c. It proves, moreover, that the height of the load of earth remaining the same, the thickness of vertical revetments increases, though in a progression a little less rapid than their height, so that in such a wall the stability of the different courses necessarily decreases in descending from the top to the foundation; which, therefore, is the course of least stability even for demi-revetments, a principle which is not evident *a priori*, and which extends to walls with the face in batter, provided that the inclination n to the vertical does not exceed $\frac{1}{8}$.

In fine, the table before us shows, as was advanced in number 23, that the nature of the masonry and earth exercises the greatest influence upon the thicknesses to be adopted in different cases; therefore, we think that when the consideration is in regard to new constructions, in which it is desired at the same time to conciliate stability with a well-understood economy, the final and essential end of all calculations, we should determine with care and by direct experiment, the density of the masonry and the earth, as well as the natural slope of the latter. The earth should be sprinkled, or slightly saturated with water, before ascertaining its density. Moreover, these experiments will be easy, if we weigh the materials entering into any regular part of the masonry, of which the cubical contents could be readily ascertained, and if we also weigh the earth after being well saturated and rammed into a space of known dimensions.

By acting otherwise in doubtful circumstances, where we are in want of examples of constructions properly established, would be trusting to chance, and perhaps uselessly augmenting the expense.

It is also from this consideration that we have not been willing, in accordance with M. Mayniel, whose table is given in a "*Recueil de tables à l'usage des Ingénieurs,*" recently published, to designate the masonry and earth by their apparent physical nature, which could easily lead to an error in the density and in the angle of the natural slope of the earth.

Besides this great influence of the given quantities of the question, and the great variations of thickness which correspond to different values of f, p', and p, have not permitted us to give enough columns in the foregoing table, so as to deduce from it, by simple interpolation, the thicknesses of revetments relative to cases or given quantities which are not directly mentioned in it; however, this table will not be the less a great resource in abridging, in each case, the calculation of these very thicknesses, of which, besides, it will immediately make known more or less approximate limits.

36. Supposing, for example, that the question should arise to calculate the proportional thickness, x, of a vertical revetment on the hypothesis of $f = 0.8$ and $p' = 1.2p$: the ratio, a, of the height of the load of the parapet to that of the wall being 2.0, and that m of the width of the berm to this same height, 0.1, we will see, in consulting the horizontal line corresponding to $a = 2$, that this thick-

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ness, which would be comprised between 1.107 and 1.004, or equal to $\frac{1}{2}$ (1.107+1.004)=1.06 nearly, if we had exactly $p=p'$ and $f=0.6$, and between 0.795 and 0.655, or equal to 0.725 nearly, if we had exactly: $p'=1.5p$ and $f=1$, must be necessarily under 1.06, and above 0.725, which gives 0.9, the arithmetical mean of these numbers for the first approximation. Substituting afterwards this approximate root in equation *(s)* of number 26, and in the expression of u given in terms of x, which, on account of $p'=1.2p, f=0.8, a=2$, and $m=0.1$, then become

$$u=\tfrac{1}{3}\,(2.08-0.8x),\quad x^2+\tfrac{4}{9}\,(x-0.1)^2(x+0.05)=$$

$$=14.337\left[2.28+3u^2+3.125u^3-4.0505\,(0.64+u^2)^{\frac{3}{2}}\right]$$

we find for the first member of this last equation, 1.08022, and for the second member, 0.55295; which indicates that 0.9 is too great, and that the true root is comprised between 0.9 and .725, so that it can differ but little from their mean 0.813, or more simply 0.8.

This last number, introduced in its turn, in the place of x in the equation, will give respectively: 0.82511 for the first member, and 0.78861 for the second member; which shows that the value, 0.8, is a little too great, but approaching, however, very nearly to the true value. Dividing, now, one-tenth the difference of 0.9 and 0.8 into parts proportional to the absolute differences 1.08022 — 0.55295= 0.52725, 0.82511 — 0.78861=0.0365, of the respective values of the first and second members, obtained in one and the other substitutions, we shall finally obtain $x=0.8-\frac{0.03650}{0.56375}\,0.1=.794$. A degree of approximation sufficient for the particular nature of the question.

Thus, by the aid of the foregoing table, two substitutions alone in equation *(s)* will suffice to obtain, without hesitation or trial, the thickness of any revetment relative to given quantities distinct from those which it contains. In truth, the example which we have chosen, refers to a case where the value of a is found immediately inscribed among those of the first column of this table; but it is readily perceived that these last values corresponding to thicknesses sufficiently exact, it will always be easy, by the rule of proportional parts, to then find those belonging to any particular value adopted for a. It is thus, by example, that if in the place of $a=2$, we should have $a=2.22$, it would have sufficed to substitute for the four thicknesses, 1.107, 1.004, 0.795 and 0.655, which are found inscribed opposite the value $a=2$, the new thicknesses $1.107+\frac{0.22}{0.50}\,0.044=$ $1.126,\ 1.004+\frac{0.22}{0.50}\,0.033=1.019$, &c. &c., since 0.044, 0.033, are the increments given to these numbers, from $a=2$, to $a=2.5$.

Practical formulas for calculating the thickness of vertical revetments on the hypothesis of rotation.

37. The inspection of the table of number 34, shows that the thicknesses due to the greatest loads of earth, follow a very complicated

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course with reference to the quantities p, p', f and m; it appears in consequence difficult to subject them to a law or empirical formula approximating sufficiently near the truth; but as has already been remarked at the end of that number, the difficulty does not occur to the same degree in the case of loads which do not sensibly exceed the height of the masonry. This circumstance arises essentially from the fact that all the curves or portions of curves (31 and 32,) which have for abscissas and ordinates the first values of a and of x, furnished previously (27) by the expression *(t)* then afterwards (26) by the equation, *(s)* differ very little from a right line, and can thus be represented approximatively by an analogous equation to that of article 23, and which was verified for the case of earth and masonry of mean densities.

38. Having wished at first to assure ourselves if this very simple formula could be extended to all the cases indicated in the table of number 34, we have found by a discussion relative to the limit of errors which we run the risk of committing in each of these cases:

1°. That if the vertical revetment to which it should be applied was without a berm, we can take to within $\frac{1}{13}$ or $\frac{1}{14}$ nearly,

$$x = 0.86 \text{ tang. } \tfrac{1}{2}\alpha. \sqrt{\frac{p}{p'}}\,(1+a); \quad e = 0.86\,(\sqrt{1+f^2} - f)\sqrt{\frac{p}{p'}}\,(\mathrm{H}+h)$$

from $a=0$ to $a=1$, that is to say, from no load up to one, with a height equal to that of the revetment, for all the hypotheses upon the nature of the earth and masonry, which are embraced in the table.

2°. That if the width of the berm should be comprised between 0 and 0.2 of the height of the wall, we could replace with still less chance of error, the co-efficient, 0.86, of the above formula, by the numbers 0.85, which would make it sensibly coincide with that which was proposed in advance in number 23.

3°. That the greatest errors in either formula correspond to the greatest and smallest values of a, that is to say $a=0$ and $a=1$; so that for all the intermediate values, such as would be wanted in ordinary application, the error, which we risk committing, will generally be very trifling.

39. But the tracing of the curves heretofore described enables us to attain still nearer approximate results, without complicating the formula to an appreciable degree. In endeavoring, in effect, to replace these curves by right lines in such a manner that the greatest relative error of the ordinates may be as small as possible through the whole extent from $a = 0$ to $a = 1$, we find that these right lines, for the case of $m = 0$, or of a revetment without a berm, converge sensibly to the point having for an abscissa $a = -1.126$, and for an ordinate, $x = -0.055$, and meet the axis of x at points which are at distances from the origin equal to 1.0443 times the ordinates belonging to the corresponding intersections of the curves; so that if we should call i these ordinates which, in the case of m and a equal to zero, the one in question, and also having a stability equal to that of the mean revetment of Vauban, are furnished (27) by the expression,

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$$i=0.7982 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}=0.7982\,(\sqrt{1+f^2}-f)\sqrt{\frac{p}{p'}},$$

we shall have

$$x=1.0443\,i+\frac{(1.0443i+.055)}{1.126}\,a$$

$$=0.74 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}\,(a+1.126)+0.0488\,a,$$

a quantity which will approximate to within $\frac{1}{12}$ nearly of the true value, for all the extent indicated, and for the hypotheses made upon f and $\frac{p}{p'}$ in calculating the table.

40. The berm exercising an appreciable influence in augmenting, as we have seen, (21 and 26,) the thickness a little in the case of small loads, and in diminishing it, on the contrary, in case of great ones, we have sought to introduce its influence approximatively, but only, however, within the extent comprised between $a=0$ and $a=1$, by means of an additive term of the form $k\,m\,(l-a)\,(a-g)$, which, in fact, possesses the indicated property, and in which k, l and g are numerical co-efficients, determined in such a manner as to render the greatest errors relative to x a minimum.

The discussion and comparison of the results furnished by the above value of x, with the numbers in the columns of the table (34) relative to $m=0.2$, moreover, make us recognise the necessity of introducing the quantities f, or cot α and $p:p'$, as factors, or divisors, of the constants l and k, which leads us to the expression

$$0.56\,m \text{ tang. } \alpha\,(0.6\frac{p}{p'}-a)\,(a-0.25),$$

and consequently to the formula

$$(v)\quad\left\{\begin{aligned}&x=0.74 \text{ tang. } \tfrac{1}{2}\,\alpha \sqrt{\frac{p}{p'}}\,(a+1.126)+0.488\,a\\&-0.56\,m \text{ tang. } \alpha\,(a-0.6\frac{p}{p'})\,(a-0.25),\end{aligned}\right.$$

which represents, to a very satisfactory degree of approximation, the results of the table between the limits $a=0$ and $a=1$, but which it does not answer to extend to cases where the width of the berm exceeds to any degree one-fifth of the height of the revetment; for here again, the quantities m, f, p, and p', have among themselves, and with the variable a, too complicated relations for us to hope that the expression in question may have an analytical form properly adapted to the nature of the question, even under a merely approximate point of view.

41. The same consideration would make us equally hesitate to extend the application of these formulas to values of the co-efficient of stability very different from 1.912, the one which we have adopted, and the square root of which enters implicitly as a factor into the expression for i, which then takes the general form

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$$i=0.790 \text{ tang. } \tfrac{1}{2}\, a \sqrt{\frac{\delta p}{1.912 p'}} = \text{tang. } \tfrac{1}{2}\, a \sqrt{\frac{\delta}{3}\frac{p}{p'}},$$

which gives in place of the above formula, (v),

$$(x) \left\{ \begin{array}{l} x=0.927 \text{ tang. } \tfrac{1}{2}\, a \sqrt{\frac{\delta}{3}\frac{p}{p'}}\ (a+1.126)+0.0488\, a \\ -\,0.56\, m \text{ tang. } a\,(a-0.6\frac{p}{p'})\ (a-0.25.) \end{array} \right.$$

In general, when the constants, or co-efficients, of a formula of interpolation are functions at the same time of several of the given quantities of the problem, it becomes so much more difficult to obtain an approximate analytical expression for it, that it is necessary to verify it by a multitude of combinations of these given quantities. These considerations should make us renounce the hope of discovering a practical rule, general, and still sufficiently simple for the case of great superincumbent loads; but the regret is less, when we reflect that the case, where the height of the load exceeds that of the masonry, is rarely presented in fortifications; furthermore, according to the calculations of M. Audoy, revetments then run more risk of sliding on the foundations, than of turning over the outer edge of the base of the wall; so that we ought principally to have in view this latter kind of movement in establishing the conditions of equilibrium.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 85.]

SECOND COURSE.—LECTURE I.—RAILWAYS.

Mr. Vignoles commenced by saying, that, in pursuance of the order stated in his introductory lecture, he would proceed to investigate the principles upon which railways should be laid out under varying circumstances. In calculating the power (of whatever description it may be) necessary to overcome the resistance of a load to be moved on any railway or road, it may be divided into two parts, viz: that necessary to overcome gravity, and that required to meet friction. The former is, of course, common to, and equal on, all descriptions of roads deviating from the horizontal line, and is in proportion to the sine of the angle of inclination; the latter is regulated by the degree of perfection of the road, and of the vehicles moved upon it, and includes the resistance of all obstacles to the rolling surface, or periphery of the wheel, in addition to the axle friction due to the load or weight placed upon the carriage. It has been assumed, from experiments and observation, that the average friction upon a railway is 9 lbs. per ton, and that this continues the same at all velocities; but there is reason to believe that the latter part of the assumption must be much qualified. The gravity due to the inclination of the plane being added to, or substracted from, the friction, as the

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plane rises or falls, the sum, or difference, will give the total amount of power necessary to overcome the resistance of the load. The power necessary to overcome the gravity being expressed by the proportion which the rise of the plane bears to the weight to be raised (say, for example, a ton,) is found by dividing 2240, the number of pounds in a ton, by the denominator of the fraction which expresses the inclination of the plane; thus, on a plane rising one foot vertically in a horizontal distance of 1000 feet, the fractional expression is $\frac{1}{1000}$, and the power (retarding or aiding the load,) will be the thousandth part of a ton, or $2\frac{1}{4}$ lbs. It is evident that, as we arrive at steeper inclinations, this power will at length become equal to that required to overcome the friction; thus, on an inclination of $\frac{1}{250}$, it will be $\frac{2240}{250} = 9$ lbs. per ton, and this being subtracted from the friction, on a railway which is commonly taken at that same amount of 9 lbs. per ton, it results that no power is required to move a load down such an inclination, or wherever the gravity and friction are equal and balance each other. The angle that such an inclination makes is called the angle of repose, but will, of course, vary with the friction due to various descriptions of roads and vehicles. On steeper inclines than such, not only is no power wanted, but there is a gravitating power due to the descent of the plane, and so strongly does this act in steep inclinations, that it is necessary to put on the brake, to retard the velocity which it occasions. It is found, however, when a train is allowed to descend a steep plane without retardation, that, owing to the resistance of the air, it will, after acquiring a certain velocity, cease to be further accelerated; many theoretical writers have fallen into error, by supposing it dangerous to allow trains to descend inclinations steeper than the angle of repose without applying the brake. On railways where there are inclined planes of $\frac{1}{100}$, for several miles together, the trains often commence the descent at the rate of forty miles an hour, and the speed, instead of being accelerated, has been quickly reduced to little more than the thirty miles an hour, or to such uniform velocity that a railway train will acquire on that inclination, varying a little with the weight of carriages, or the length of the train; such being the case, it is evident that lines of railway for locomotive power, can be safely laid out with inclinations of 1 in 100, and even steeper.

It is of the utmost importance, in laying out a line, to consider the power which is proposed to be employed, and the mode of obtaining it; thus, if it be intended to lay out a horse railway, to carry coal from a colliery to a shipping place, the line should be made always to descend, and so regulated, that the number of full wagons that may be sent down be that number which may be taken back empty. But horse-power being extremely limited, recourse is had to steam, and the locomotive steam engine has been applied to railway traveling, as being better suited to the purpose than animal power. The power of the locomotive engine may be defined, not so much by horse power, or cylinder power, as by boiler power, or capability of rapidly supplying steam to the cylinders, and still more by adhesive power, or the weight insistent on the driving wheels, so as to have

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purchase, as it were, to drag the load after it, for the wheels will slide, more or less, and, under some circumstances, will merely turn round on the rails, without progressing. Many lines appear to have been laid out under the impression that the locomotive engines would always have to carry a *maximum* load, and, in accordance with this principle, and to enable them to do so, it was some short time since laid down as an axiom, that no inclinations should exceed $\frac{1}{330}$, and that gradients should be constantly uniform through the whole length of a line. Experience has shown, however, that the practical cost of conveyance of ordinary trains over lines greatly varying in their gradients, does not materially differ, the wear, and tear, and fuel, seldom being increased so much as 10 per cent., and other expenses and contingencies being the same, whatever the gradient of the railway, the difference on the whole expense of working and maintenance becomes very small indeed. In laying out a line, then, the traffic must be considered quite as much in the distribution of it as in the totality; for it is evident that, to accommodate the public, the trains ought to go often, and will, therefore, generally be light; and when we consider the great economy in construction, and the little additional expense incurred in the after working, we may conclude that railways may be advantageously laid out with much steeper inclinations than they have in general hitherto been, particularly in the remoter districts, where the railway system has not yet been extended. A powerful engine will draw an immense load on a level, whereas it often has not more than twenty tons to draw—consequently, gravity ceases to become an object; and even should the traffic increase in course of time, it will be better to send frequent and light trains, than in the original construction, to incur heavy cost to graduate the road for heavy trains, which are seldom to be carried. This principle must, of course, be confined within certain limits; thus, lines may be laid out with better gradients, where the traffic is very great, and will justify the expense and inconveniences which might result from an engine having always to go up a steep ascent. Railways in England have cost, on the average, £30,000 per mile, and the first cost of locomotive power does not amount to one-fifteenth of that sum. The interest on the capital is, therefore, very great, while that on the power is small, as is also, comparatively speaking, the daily cost of transit due to the power only. If these proportions were different, the latter being increased, while the larger amount (the interest on the cost of the works) were diminished, the capital sunk in railways might have been reduced fully one-half, with equal satisfaction and benefit to the public, for whose use they were designed, and with greater profit to the shareholders.

LECTURE II. RAILWAYS—LOCOMOTIVE POWER.

In the last lecture it had been stated that the adhesive power of the locomotive engine depended upon the weight borne upon the driving-wheels. The greatest amount of adhesion of iron upon iron, according to the experiments of the eminent engineer, Mr. George Rennie, as published in the *Philosophical Transactions*, appears to

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be about one-sixth or one-seventh of the weight of the insistent load. In the locomotive engine, where the bearing of the wheels is upon smooth surfaces, the adhesion will, of course, be less; and in weather when rime or mist congeals upon the rails, it is very small indeed, sometimes none at all. But in ordinary states of the rails, and of the atmosphere, one-fifteenth may be taken as an average. The vicissitudes to which this power is subject, will often account for the varying rates of railway traveling, and it is only when the resistance of the load is less than the smallest amount of adhesive power which the state of the weather or the rails will admit, that the time of transit of a train over any given distance can be insured. Now, the usual weight bearing upon the driving-wheels of an ordinary locomotive for passenger traffic, is about seven tons, or 15,680 lbs.; one fifteenth of this will be 1042 lbs., or, in round numbers, say 1000 lbs., for the average available adhesive power of such an engine for moving a load, and on the amount of this alone will depend the weight which the locomotive engine can draw after it. The other principal element which must be taken into account in the locomotive engine—viz. the speed—will depend mainly upon the power of the boiler to generate steam with sufficient rapidity. A boiler may have quite sufficient power to move (at a velocity of three miles an hour) a load of which 1000 lbs. shall be the representative, but it must be of a far superior description, and far higher powers, to move the same load at a velocity of thirty miles an hour; and this subject does not appear to have been sufficiently considered, though it is of such paramount importance thoroughly to understand the nature of the moving power to be used, before going into the subject of the gradients, or the principles of laying out the line. The amount of the load, then, which the engine can draw, will depend chiefly on the adhesion, and the velocity will depend on the boiler where the steam is generated, the cylinders being proportioned to each of these two other regulating powers. And not only must the steam be generated to a given pressure to produce that power, but with sufficient rapidity to continue it; and in keeping up a high velocity, it must be, as it were, rammed into the cylinders, so as to produce the greatest possible effect in the least possible time, and this is the reason why high velocities are so very expensive, as the same effect might be produced by one-fourth the quantity of steam, if sufficient time were given to expand it. But there is yet another circumstance that modifies the amount of adhesion—viz. the inclination of the road. It is manifest that, if the road were vertical, the engine could have no adhesion upon the rails; and, therefore, between the perpendicular and horizontal lines, the power must undergo many degrees of variation, quite independent of the atmospheric causes already mentioned. We have no experiments to determine the ratio of that variation, but, reasoning from analogy, it may be assumed to be as the sine of the angle of inclination, or in the same proportion as the resistance arising from gravity, so that practically the diminished amount of adhesion, on any inclined plane, might be found by deducting the resistance of gravity on that plane from the constant of 1000 given above; thus, on an inclination of 1

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in 100, the gravity of the engine per ton (or 2240 lbs.) will be $\frac{2240}{100}$ = 22.4 lbs., and that for seven tons will be 22.4 + 7 = 157 lbs., which subtracted from 1000, will give 843=the diminished amount of adhesion, which will be the limit of the power of the engine on that incline, as regards the load, no matter how great the boiler or cylinder power may be. And to find the load which this power will draw, we must take the sum of the resistances arising from gravity and friction for one ton, and the adhesive power divided by this sum will be the amount sought in tons; on an inclined plane of 1 in 100, the calculation will be found thus:—Friction 9 lbs. per ton, *plus* gravity as before, 22.4=31.4 lbs., and adhesive power 843, divided by 31.4=26.7 tons, which is only one-fourth of what might be drawn on a horizontal line. Hence the advantage of heavier engines, which are daily coming into use, as also the propriety of coupling the wheels of engines for drawing heavier loads up steep inclines, and by this means the whole insistent weight of the engine is rendered effective by adhesion, and the load the engine can draw after it proportionally increased. In calculating the amount of resistance of a load upon a railway, the friction had been assumed to be 9 lbs. per ton, rather in deference to general opinion than otherwise; it was probably much higher. It is considered that the friction of the engine and engine gear is 16 lbs. to the ton, but that of the lighter carriages less; however, if this number (9 lbs.) should be proved incorrect by future experiments, the principle of the calculation will not be altered, and it will only be necessary to substitute the true number instead of 9. The same may be said with regard to the adhesion; it will only be necessary to substitute for 1000 whatever number shall be found on closer investigation to be nearer the truth.

The power generated in the boiler, and applied in the cylinders, now remains to be brought under consideration. This may be stated to be the capability of the boiler to supply steam of high pressure, to enable the piston to perform a given number of strokes per minute, which accordingly will be one of the essential elements in computing the power of the engine; and therefore it is that we are always unwilling to define it by any number of horses' power, since it is clear that the engine which, moving at the rate of 15 miles an hour, would be called a 20-horse engine, would be styled a 40-horse engine when moving at the rate of 30 miles an hour, all other circumstances remaining the same. But it does not follow that, because the number of strokes per minute be increased, that the power available for locomotion be increased also, and in this consists the essential difference between locomotive and stationary engines, for in the former there are circumstances, as before shown, which circumscribe that power, over which the boiler has no control; and, as regards the locomotive engine, a third point must be taken into consideration. It is a well-known theory, that, if a metallic substance be in contact on one side with water, and that heat be applied to the other, that once the body becomes thoroughly warmed, the caloric will be taken up by the water with as much rapidity as it can be supplied to the metal. Now, in the locomotive engine, there is an immense area of heating surface

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in contact with the water in the boiler, in consequence of the numerous tubes which pass through it from the fire-box to the chimney, and it is on this principle that what is called the steam draft has been introduced, by which means the caloric is rapidly drawn from the fire through these tubes, and as rapidly absorbed by the water with which they are in contact, for the production of steam. It is evident that, in proportion to the rapidity with which the piston moves, and with which the waste steam is injected into the chimney, will the heat be absorbed by the water from the tubes and steam generated, the effect of which is, that the faster the engine goes, the quicker it generates the steam; and this forms another great beauty and peculiarity in the locomotive engine. The principles of calculating the moving power being thus explained, the way has been sufficiently cleared for entering on the subject of the laying out of railways.

Lecture III.—After recapitulating a few of the leading points which were stated in the last lecture, the Professor called particular attention to the formula whereon he had based the calculations into which he had then entered, and he now exhibited tables and diagrams in further illustration. The adhesive power of 1000 lbs. was assumed as the average of what a locomotive engine will have in all states of the weather, and of the rails; but if the wheels be coupled, or the insistent weight otherwise increased or diminished, the adhesive power (on which depends the load) will be altered in the same proportion, subject also to variation from the state of the weather and the road, and undergoing the stated diminutions from the effects of gravity on all planes which depart from a horizontal line, the velocity of the train depending on the evaporating power of the boiler. But in the stationary system the engine winds (upon a roller, or over a sheave or wheel) a rope supported by pullies, placed at regular distances along the road, and to which rope the train is attached. Mr. Vignoles stated that the student may refer with confidence for every information on this subject, to Mr. Wood's *Treatise on Railways,* and commented on the extracts he made from that work.

Atmospheric Railway.—There is also another mode of applying the stationary engine to the purposes of locomotion, by producing through an air pump a partial vacuum in a pipe, thus making atmospheric pressure the moving power; and it may be interesting to state, that the scientific men who were appointed by the railway department of the Board of Trade to inquire into the system of the Atmospheric Railway, had fully recognised that principle, and concurred in considering that the experiment contemplated upon the Dublin and Kingstown Railway extension, and recommended by the directors to the proprietors, as applicable for illustrating the principle on a large scale. On the atmospheric railway the diameter of the pipe or tube regulates the load, but the velocity depends almost entirely upon the diameter of the air pump that exhausts the pipe, the rule being that the area of the air pump must be made as many times greater than the area of the pipe, as the velocity of the train is to exceed that of the piston of the air pump. Thus, if the piston of the air pump be supposed to move at a rate of three miles an hour, and it be required

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to move a train at a velocity of thirty miles an hour, the area of the air pump must be made ten times the area of the pipe; the diameter will, of course, be deducted from that area. Now, it appears that the most economical pressure in the pipe (which is what engineers must chiefly look to,) is about 7 lbs. to the square inch, or rather less than half a vacuum; therefore, this may be taken as the constant of the atmospheric pressure; and if we multiply this constant by the area of the traveling piston in inches, we shall obtain the effective pressure upon that piston, which, as it regulates the load, may be said to correspond to the adhesive power in the locomotive engine, but which, unlike that power in the locomotive, will be undiminished on inclined planes. Again, if we divide this power by the friction (which was before taken at 9 lbs. to the ton,) we shall obtain the number of tons which the piston, acted on by the atmospheric pressure, is capable of propelling. Thus, supposing we have a pipe of 14 inches diameter, if we multiply the area of this pipe by 7 lbs., we shall find the effective pressure equal to 1078 lbs., which, divided by the friction, 9 lbs., will give about 120 tons—the weight which can be propelled by means of a pipe of that diameter; and if the piston of the air pump move at the rate of three miles an hour, and its area equal to seven times that of the pipe, the load will be moved with a velocity of twenty-one miles an hour, and it may be demonstrated that, on ascending and descending planes, the speed, although increased or diminished at first, will soon become uniform. Of course, upon the diameter of the air pump will depend the power of the engine which is to work it. The calculations in this case will be similar to those for an engine required to work ropes—in the one case it being required to find what is wanted to overcome the resistance and friction from ropes, pullies, &c., and in the latter to find the power to work the air pump, and exhaust the air from the tube at any required velocity.

Inclined Planes.—The Professor then recurred to the effect of trains descending inclined planes. Mr. Navier (in his work, translated by Mr. M'Neill, which he mentioned as a text book on the comparison of different lines of railway,) differed somewhat from the propositions he had laid down; it was therein stated, and Professor Barlow concurred in the statement, that an engine and train did not gain any advantage in descending planes steeper than a certain inclination which they have put as the angle of repose. Now, in practice, Mr. Vignoles did not find it so, but, on the contrary, daily experience proved that, as far as inclinations of sixty feet in a mile, the trains may, under almost all circumstances, have the full benefit of gravity in the descent. Professor Barlow has laid down, in several important works, which, from their high standing, will have a material influence upon the public mind, that though additional power be required to surmount steep inclinations, yet, so far from gaining a corresponding advantage in the descent, there will result rather an injurious effect from the necessity of applying the brake. Now, it has been already mentioned, and experiments have been repeatedly made by Mr. Wood, Dr. Lardner, and others, showing that, when

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engines descend long inclined planes, such as those on the Croydon Railway, the application of the brake is seldom necessary, the speed that would be due to the accelerating force of gravity, being reduced by the resistance of the atmosphere, until it settles down to a uniform and safe velocity. It is evident, therefore, that there is a great deal yet to learn on this subject, when we find authority and practice differing so materially. Mr. Vignoles observed, in conclusion, that, as the laying out of the lines of railway ought to be strictly regulated by the power to be used for locomotion, as well as of the load of each train, and the nature of the traffic, it becomes interesting to consider these principles in respect of the extension of the railway system in this and other countries; for, looking at the enormous outlay hitherto incurred, lines through remote districts would not be undertaken, unless the first cost of railways, and the annual expense of working and maintaining them, were reduced to a *minimum.*

To be continued.

Description of a Bridge of Béton, (Concrete,) constructed at Grisoles, in the Department of Tarn-et-Garonne, in France.† By* M. Lebrun, *Architect, of Montauban.*

Translated for the Journal of the Franklin Institute, from the "Bulletin de la Société d'Encouragement pour l'Industrie National," for July, 1842. By Ellwood Morris, Civil Engineer.

Living in a region where suitable building stone is scarce and expensive, and where brick masonry alone is used, M. Lebrun, guided by the fine works of M. Vicat, on hydraulic limes, conceived the idea

* The French *béton* is nearly identical with the English *concrete,* the main difference being in the manipulation; thus *béton* is composed of lime, sand, and small pebbles, or broken stone, *taken separately,* and successively mixed together, the pebbles being added last; while *concrete* is usually formed of lime, mixed directly with gravel, *containing naturally* about the due proportion of *pebbles and sand;* proper quantities of water being used, and the factitious stone resulting, in both cases, being in effect the same.—Tr.

† Béton, or concrete, has before been used in retaining walls and other constructions, and, as is stated by Gen. Pasley, of H. B. M. corps of Engineers, (in his admirable Treatise on Calcareous Cements,) it was also applied experimentally to build a military casemate near Woolwich, of which the arch had 18 feet span, 5 feet rise, and 6 feet depth at the crown, and which, when subjected to the direct fire of 24 pounder guns, as well as the vertical plunge of 13 inch shells, loaded to weigh 200 lbs. each, resisted both with success, and, contrary to expectation, was less injured by the latter, than by the former.

General Treussart, of the French army, after mentioning the successful construction of several concrete vaults, recommended this material for aqueduct bridges, and for the revetments of fortresses, in certain situations.

Nevertheless, the bridge above described is amongst the first, *if not the very first,* construction of that nature which has been successfully executed for ordinary use, and its success will suggest at once to the mind of the American engineer, many situations, in the southern section of the Union, at least, where concrete may thus be used with great propriety and economy; indeed, its comparative cheapness, in some cases, would fully justify a fair trial of it, even in the northern United States, though the severity of the winters, there, would seem to render its success in that region more problematical.

We must, however, observe, that the failure of the concrete wharf walls, at Woolwich and Chatham, in consequence of tidal exposure, and the necessary protection of the concrete sea wall at Brighton, with woodwork, to shield it from the action of water in mass, (as mentioned by Gen. Pasley,) points out the necessity of confining the application of *concrete* to constructions, within reasonable and proper limits.—Tr.

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of substituting for this masonry the *béton*, which the Romans used with so much advantage.

In consequence, he submitted, in 1839, to the Minister of Public Works, the project of a bridge entirely of *béton*, which he offered to construct on the lateral canal of Garonne, to be traversed by many of the royal and departmental routes. This offer having been accepted, under certain conditions, M. Lebrun commenced his work in June, 1840.

I.—*Selection and Preparation of the Materials.*

The *lime* was of the hydraulic quality, burnt in perpetual kilns, by pit coal. The *sand* was clear of all earthy particles, of fine grain, and pretty uniform. The *gravel stones*, of the size of a hen's egg, came from the river Garonne. The lime was slaked alternately in two basins, joined together. For this purpose, we poured at first, in one of the basins, a quantity of water proportioned to that of the lime which we wished to slake; we then put in sufficient quicklime for the water to cover it; then we left the lime to slake freely without disturbance, except by taking care to prick it, from time to time, with a stick, to introduce the water into those parts of the basin where the dissolved lime was dry. When the fermentation had ceased, we stirred up the lime in every direction with an iron hoe, in order to mix the paste, and render it homogeneous; we left it then in this state, not to be used for twelve hours after slaking.

The proportions observed by M. Lebrun for concretes (bétons) destined for the construction either of walls or arches, were, in every ten parts, composed of two parts of lime in paste, three parts of sand, and five parts of gravel stones, or pebbles.

For making the mortars, we placed, on a paved surface, two measures of the slaked lime, which, after having been well beaten with pestles of cast iron, softened again by yielding up a part of the water with which it was charged; then we placed beside it three measures of sand, which we mixed, little by little, with the lime, always having the aid of the pestles, and stirring the whole with the shovel and hoe, in order that all the parts of the sand should be well incorporated, observing not to put any water into the mortars, but, if the sand was too dry, we moistened it, a few moments before mixing. As soon as the mortars were sufficiently manipulated, we added five measures of gravel stones; the whole was then long and forcibly mixed and pounded, until each part of the gravel was sufficiently enveloped by mortar; then the *bétons* were taken in quantity, to wait for the moment of being used. We took care to make only what we could employ in a day's work, without which precaution it would have lost its cohesion.

II.—*Construction of the Abutments.*

The 15th of June, 1840, the excavation of the foundations of the two abutments being done, we commenced laying the *bétons*, taking care, each time that a layer, or course, was finished, to cover it up

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immediately with wet mats of straw, to prevent a too rapid drying by the heat of the sun. By means of this precaution, the new course connected itself more intimately with the one below. We continued the masonry all of *béton*, (the backing of the arch and abutments keeping pace,) until reaching the height fixed. The exterior faces of the abutments, (not next the earth,) and of the walls, were formed by some planks strongly fixed, against which the *béton* rested. These planks were removed, two or three days after, and the faces of *béton* remained exposed, and were very well preserved. At the height of the springing of the arch, we laid five courses of bricks plumb on the faces of the abutments, to serve as perpendicular faces for the centre to fit up against, and enable it to detach itself easily.

III.—*Construction of the Centre.*

Fifteen days after the laying of the last *bétons*, we commenced the construction of the centre, composed of many courses of bricks, laid flat, in succession, (from the spring towards the crown,) following the curve of the arch at the intrados, built partly with plaster, and partly with cement, or hydraulic mortar, and supported at the springing by projecting masonry, or by a timber for that purpose. The centre was formed of four courses of bricks, (in thickness, or depth, say nine inches;) the three lower were laid with plaster, and the upper course with cement, to shelter the plaster from the dampness of the *béton*. The upper bricks of the centre were covered by a bed of mortar of clay, in order to model perfectly the intrados of the arch, and to hinder the *béton* from forming one body with the bricks.

The construction of the centre being finished on the 17th of August, we established, three days after, the masonry of the two heads of the arch of brick, (in lieu of ring stone,) which were completed on the 26th of the same month.

IV.—*Construction of the Arch.*

Immediately after the construction of the two heads, we wrought them into the general mass of *béton*, forming the arch; this operation was finished on the 5th of September, with the exception of the backing up, which was accomplished, on both sides, the 11th of the same month. The *bétons* of the arch were composed in the same manner as those of the abutments, and manipulated by the same process; but we added to it $2\frac{1}{10}$ cubic feet of *cement* for every $35\frac{1}{3}$ cubic feet, or $\frac{1}{17}$th, of the mass, to augment the strength of the mortars of the body of the arch. This construction was made without following any regular order, and the *bétons* were cast in masses, upon the centre, to the thickness of two feet, which formed the first general bed, or layer, on the development of the arch. This first bed being finished, we formed the second in order to reach the thickness of three feet at the key, the spandrel backing, and the abutments being leveled up. A coping of hydraulic mortar was then placed over the whole extent of the arch, and covered immediately with a layer of clay, strongly beaten.

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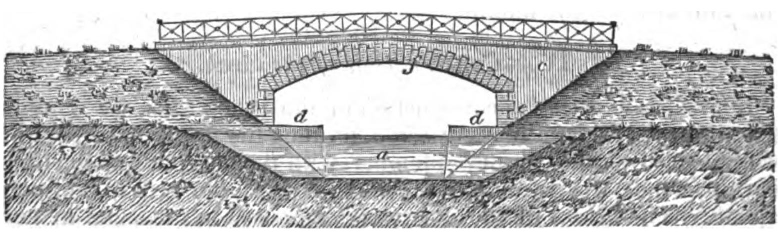
V.—*Decentrement.*

All was left in this state until the 25th of January, 1841; we then proceeded to the operation of the decentrement of the arch. The 28th of January, the centre of bricks was taken away, and the intrados of the arch appeared very even in all its parts. After three months, it manifested not the smallest settlement in its masonry, and, since then, the bridge has stood through the summer, without incurring the least degradation capable of affecting its solidity. This bridge has a clear opening of 39$\frac{1}{3}$ feet between the abutments; the middle is placed in the axis of the canal, which has two towing paths; its breadth is 19$\frac{2}{3}$ feet between the heads, or faces, of the rings; and the arch is formed of a segment of a circle of 39$\frac{1}{3}$ feet chord, and 5$\frac{1}{4}$ feet rise, or versed sine.

The entire mass of the abutments is of *béton*, except the four angles on the sides of the towing paths, which are of large stone, rounded on the arris, on account of the rubbing of the towing lines. The arch is also of *béton*, as are the faces of the tympans, or spandrels, and the intrados, with the exception of the arrises of the soffit, or rings of the heads, which are of brick masonry.

M. Lebrun has joined to his memoir, along with a plan of the bridge of Grisoles, many certificates, from the mayor of this commune, and from the engineer of the lateral canal of the Garonne, proving the complete success of the works, and the solidity of the construction, which has endured the proof of the passage of loaded carriages, the numerous influences of heat, and some very severe frosts, without having suffered the least degradation.

VI.—*Explanation of the Figures.*



a, canal.
b, abutment of *béton*.
c, mass of arch, also of *béton*.
d d, towing paths.
e, angles of bridge upon the tow-paths, built of large stone, with the angles rounded.
f, arrises of the soffit, or bands of brick at each head of the arch, instead of the usual ring-stone.

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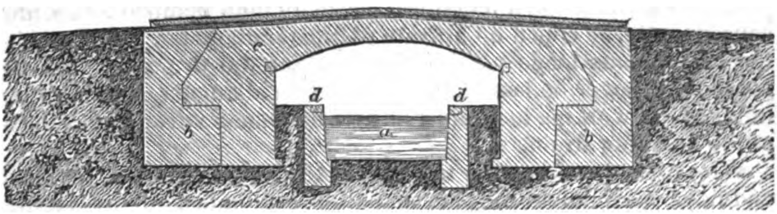

On the Advantage of Wire Rope over Hempen ones. Extracts from the Mining Journals of Freiberg. Arranged for the Journal of the Franklin Institute, by Theo. F. Moss, *Mining Engineer, Philadelphia.*

Since the introduction of the wire ropes in the mines of Saxony, experience has proved them to be more advantageous than hempen ropes, both in cheapness and in durability, which has warranted their general introduction into all the mines of Saxony.

The price of hempen rope of 288 threads, is, per lachter, (equal to two French metres, or 78⅝ English inches,) 1 thaler 20 groschen, about $1.27½ of our money. An iron wire rope, used in the place of the above hempen rope, costs, per lachter, 15 groschen 3 pfennings, or about 46 cents; therefore, the price of the hempen rope of 288 threads is, to the price of the wire rope which replaces it, as 1 is to 0.3483; consequently, the wire rope is 65.17 per cent. cheaper than the hempen rope.

The price of a hempen rope of 336 threads, the largest used in the mines, is 2 thalers per lachter, or $1.38; this is replaced by wire rope of 16 wires, which costs 47 cents per lachter, or in the proportion of 1 to 0.3405.

Hence, the wire ropes are two-thirds cheaper than the hempen ropes which they replace, and, under many circumstances, of greater durability, particularly in moist situations, or where the rope remains for a long time coiled on the drum, when it decays from mildew.

Besides these advantages, the wire ropes are one-third the weight of the hempen rope which they replace.

Wire rope of 12 wires weighs, per lachter, (equal to 2 French metres, or 78⅝ English inches,) 3.4309 pounds; hempen rope, of 288 threads, weighs 9.62 pounds, or as 0.3536 is to 1.

The wire used is 3.3 millimetres in diameter, equal .039 inches, and the strength of the wire ropes is in proportion to the number of wires. The wear and tear of wire ropes is less rapid than by hempen ropes; consequently, the hempen ropes, to have an equal durability with wire ropes, must, at the outset, be much stronger.

The maximum strength, or breaking strain, of hempen ropes of 288 threads, is, expressed in pounds, equal to 19,800 pounds; whereas the breaking strain of the wire rope of 12 wires, used in the place of the above hempen rope, is, when new, 11,200 pounds.

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Wire ropes, having a much less elasticity than hempen ropes, must, consequently, be coiled on a drum of greater diameter. The result of the experiments made at Freiberg, is, that the drum for iron wire ropes must never be less than eight feet in diameter, and the maximum of the working load must be between one-sixth and one-seventh of the breaking strain.

Wire ropes have been in use since 1834 in the mines of the Harz, and have been lately introduced at the coal mines of the northern counties in England, and on most of the railroads where stationary engines are used.

Messrs. R. S. Newell & Co., Patent Wire Rope Works, Gateshead, county of Durham, Eng., publish the following comparative card:

Comparative Table of the size, weight and cost of Hemp and Wire Ropes.

Hemp Ropes. Circumfer'e in inches.	Hemp Ropes. lbs. weight per fathom.	Hemp Ropes. Cost per fathom.	Wire Ropes. Circumfer'e in inches.	Wire Ropes. lbs. weight per fathom.	Wire Ropes. Cost per fathom.
		s. d.			s. d.
3	2¼	0.10	1¼	1¼	0.11¼
4	4	1.6	1¾	2¼	1.7
5	6¼	2.4	2⅛	3½	2.2
6	9	3.4½	2½	5	3.2¾
7	12¼	4.7	2⅝	6¾	4.2¼
8	16	6.0	3⅜	9	5.5¼
10	25	9.4½	4⅛	14	7.10½
12	36	13.6	4½	20	10.5

Newell & Co.'s scale price of Wire Rope.

lbs. weight per fathom.	Breaking strain.	Working load.	Price per cwt.
lbs.	ton. cwt.	ton. cwt.	s. d. s. d.
2	3.12	0.12	80 *a* 75
3	5.8	0.18	
4	7.4	1.4	
5	9.0	1.10	75 *a* 70
6	10.16	1.16	
7	12.12	2.2	
8	14.8	2.8	70 *a* 67 6
9	16.4	2.14	
11	19.16	3.6	67 6 *a* 65
13	23.8	3.18	
15	27.0	4.10	65 *a* 62 6
17	30.12	5.2	

Facts and Observations on Four and Six Wheel Engines.

By JOHN HERAPATH, ESQ.

[Continued from Page 89.]

Eastern Counties Railway.

The Eastern Counties Railway is the longest projected line in England, being 126½ miles from its commencement in London to its terminus at Yarmouth. Its original projection was in 1834, but owing to some political affair at Ipswich, it was abandoned, and renewed again in the year 1835.

A very remarkable feature of this line is its not having a single tunnel throughout its entire length, 126½ miles. Such an instance, perhaps, is unparalleled in British railways.

At present there are only 17½ miles completed, namely, from London to Brentwood, but in the fall the remaining 33½ to Colchester it is fully calculated on will be opened to the public.

The rails are 75 lbs. rails, laid upon cross sleepers, which we un-

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derstand, in cuttings are 5 feet apart, but on embankments about 3 feet 6 inches.

One of the heaviest works is the Brentwood Hill cutting through clay, which is 1¾ mile long, and averages about 40 feet deep. Here is an incline of 2½ miles long, at 52¾ feet per mile.

A very troublesome work also is what is called the Gubbins embankment, which is 2½ miles long, and 30 feet high, on the London side of the Gubbins cutting. This embankment is composed of a soapy clay of a very treacherous description, and has given great annoyance to the Company. They are now piling it at the sides, and carrying immense cross timbers right through the embankment, from pile to pile, on which longitudinal bearings are laid for the rails to rest on. It is contemplated by this means to get rid of, in future, all the annoyance of any sinking in the material, and preserve a good sound road.

We perceive, at the London end of the line, they are turning the arches into storehouses, carriage offices, &c., which must necessarily save the Company a considerable sum in buildings or rental. As far as I saw, the old arches were quite dry, and well adapted for the purposes to which they are applied. Here I had an opportunity of inspecting the manner in which they kept their store accounts, which was both simple and effective.

As this viaduct runs through a very populous neighbourhood, it is not improbable but that the Company may eventually turn the arches to account, in the way of letting them either as storehouses, or for other purposes, and of course realise, if all let, a good round rental per annum.

The station at this end of the line is large, and may be made very commodious for the two Companies—the Eastern Counties, and the Northern and Eastern; but at present it is unfinished. It is 260 feet long, and 130 feet wide. The roof, which is made of corrugated iron, is divided into three compartments, and has an extremely light and airy appearance, so much so, that we should be inclined to think with the first high wind it would be blown away. However, it has now stood one or two winters, and has put beyond a doubt the question of its stability.

One of the peculiarities of this line is the signals for the stopping and regulation of the trains. This ingenious system is the invention of Mr. Hall, the present manager. By this code of signals a man is saved at every station. For the policeman who has the care of the signals, which are 100 yards from every station each way, being able to let down or raise the signal without leaving the station, can lower it the moment a train passes it, and be ready to attend to the passengers before the train reaches the station. The signal consists of four compartments, leaves, or panels, each being the 16th part of an entire circle. These panels are let down by a policeman immediately on a train passing, with the colored spaces or sides towards the parts from which the train has come, and it is allowed to remain so five minutes after the train has passed, when the lower panel begins to wind up slowly behind the next above it, either by means of clock-

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work, or windlass and pullies. At 7½ minutes the two lower ones are pulled up behind the second, and at the end of ten minutes, the second, third, and fourth are pulled up behind the first, and the whole wound up at the end of 15 minutes. The panels are painted, yellow the first; green the second; and red the third and fourth. By the manner of managing these signals, the time at which a previous train has passed is known. Thus, if all the panels are down, a train cannot have been gone five minutes; if only three are exhibited, it cannot have passed 7½ minues; if only two, ten minutes; and if they are all drawn up into the box, it must have passed at least, 12½ minutes before. A man at one point can work easily three of these signals, at 150, or 200 yards from him on either side. The colors are also made to signify the speed at which the trains are to travel. For instance, if any part of the two red panels is visible, no train is allowed to pass. If the yellow and green, their speed must not exceed 15 miles an hour, until they arrive at a post with green and white stripes a mile onward. If only the yellow is visible, the rate must be reduced to 24 miles an hour, and if they are all boxed up, the line is clear, and they may go at their usual speed.

This is the completest code of signals I have yet seen.

My first trip down the Eastern Counties line was on Saturday, Jan. 22nd, with Mr. Hall, the manager. We went down as far as Stratford on No. 11, and returned on No. 17, engines. Both these engines were Bury's make, and four-wheel engines. No. 11 had been out for some months, hard at work, and, notwithstanding, had very little motion. No. 17 had only been out two journies, but we did not go fast enough to determine what her motions were.

April 4th I went again over the line, as far as Brentwood and back, on No. 13 engine, which had been about 9 or 10 months out. Her pressure appeared to be 60 lbs. to the inch. She had 6 feet wheels, and had no longitudinal motion when going fast. I fancied, however, she was rather loose in the brasses, though very steady at high speeds. She had a little side wriggle behind, and was rough on the platform. I went afterwards on No. 14 engine, 5½ feet wheels, 18 inch stroke, and 13 inch cylinder. This engine had no such side wriggle as the last, was smoother in her motions except on rough ground, which was owing to her coming down on her stays with every jerk, her springs not being sufficiently strong, or not having play enough. Neither of these engines had any sensible longitudinal motion, but in this respect ran very sweetly. I, however, perceived a tendency to roll and pitch in No. 14.

Except that No. 13 had 6 feet wheels, and No. 14 only 5½, these engines appeared to be counterparts of eath other.

On No. 13 we tried the experiment of suddenly cutting off the steam at high velocities, but could perceive no effect that it had upon the engine.

April 11th I went upon another engine, No. 15, her wheels, stroke and cylinder were the same as No. 14. She had no longitudinal motion, but was exceedingly sweet in her movements. I was informed she had been out 7 months, but within the last two days had had her

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brasses lined, which may partly account for her tightness and very easy motions. They were obliged to keep the water very low in this engine, in consequence of her priming so. I was informed that her ports were very large, to which the engineman attributed much of her superiority in motion.

I was glad to observe in all their engines that they had lately had sheet iron put round the platform, and that over the wheels there were brass dashing plates. The whole appearance of the Eastern Counties engines is that of extreme neatness and cleanness. They work two days and are in one, which gives the men an opportunity of keeping them clean, and of attending to any repairs that may be wanting.

On these Eastern Counties engines I noticed the same activity and facility in starting and taking off a load, which I had remarked in other four-wheel engines. Whatever may be the cause, there certainly does appear to exist *a command over the loads*, if I may so call it, in four-wheel engines, which I have never observed in the six-wheel. So striking is this circumstance, that one unacquainted with the loads would imagine that four-wheel engines seldom or ever had heavy loads after them, and that they were always reserved for six-wheel engines.

The number of engines this company have is 17, of which two are with coupled wheels, and 4 ballast engines. They have 8 more building, in preparation for the intended opening, on October 1st., of the new part from Brentwood to Colchester. The complete stock for working the entire line of 52 miles long will be 35; all are four-wheel engines, have inside bearings, and are generally from 10 to 11 tons in their working trim. The proportion of weight on the driving and leading wheels is various in the passenger engines, being in some 6 and 4 tons, and in others 5½ and 4½ tons; the coupled goods engines are 5¾ and 4¾ tons on the hind and leading wheels. The managers of this Company are much attached to four-wheel engines, from a conviction, by their experience, that they are equally safe, and in other respects preferable. The coupled engines, they say, work exceedingly well in all respects. One of the engines on this line (the one, I believe, which met with the accident at the Brentwood incline in the autumn of 1840), has had an additional pair of wheels placed under the fire box, as an experiment, in order to ascertain whether increased steadiness resulted from this addition. The experiment is said not to have succeeded; for although the engine works very well, she is no steadier than the sister engines, which have not had this addition.

The gross loads carried are from 32 to 35 tons. The cylinders are 12 to 14 inches diameter, stroke 18 inches, and diameter of driving wheels 5 to 6 feet. The steam pressure is 55 to 60 lbs.; the consumption of coke 33.35 lbs. to the mile, at present. This includes getting up the fire and the consumption during the long delays between the trains. Their consumption during the time of traveling must be much less, probably two-thirds of the amount. The total

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expense for coke, driving, materials and labor for repairs, oil, cotton waste, tools, and all contingencies, is 11.75 pence per mile.

Some of these charges the Company expect still further to reduce, particularly the consumption of coke. At present their engines *are not worked expansively to any considerable extent.* In the engines now building for the Company they intend to use large cylinders, namely, 14 inches, with 65 lbs. steam, and to work expansively to a considerable extent, and they expect to reduce their consumption of coke by this means, and by one or two other little improvements in the engines, fully one third of the present amount.

The motions of their engines are stated to be very smooth, and whatever motion they have is attributed to the road. They have no top heavy engines. *The play on the rails is three-quarters of an inch.* The cost of an engine, including tender, is £1,600.

During the time this line has been opened, nearly three years, they have had one cranked axle broken and two engines run off the rails. The broken axle was owing to defective welding, and happened with a coupled engine, but was not then working with its couplings, though it had been a day or two before. The accident happened shortly after the engine was put upon the line. After the fracture of the axle, the engine conveyed the train a distance of two miles, which was the end of the journey; and the only indication the engine man had of the failure of the axle, was a very slight degree of collapse in the upper part of the wheels, which he thought arose from the axle being suddenly strained; and he therefore slackened his speed as a measure of precaution, and only discovered that the axle was broken when the engine arrived at the station. The accident happened on a straight line, and on ascending gradient. The diameter of the delinquent axle was 5½ inches, cylinder 14, and stroke 18 inches.

The two cases of running off the rails are attributed to excessive speed down descending inclines, one being on a straight line, and the other on a curve of 1½ mile radius. It is estimated that the speed could not have been less than 60 miles an hour. The speed in descending the incline is now limited to 15 miles an hour, with a penalty on the men if that velocity is exceeded. This is a compliment to public prejudice, commendable enough, but not in my opinion by any means necessary. In both cases the wheels were uncoupled.

The maintainance of way on this line is performed by contract, which includes every description of work for the repair of the line, and for upholding in perfect order all the brickwork and bridges, painting all woodwork, watching the line, and all other charges of every description whatever, being, I believe, more comprehensive than almost any other contract of this description. The cost is, I understand, £214 per mile, the contractor finding materials and paint of every description.

About two miles below the Romford station the Company are now building an exceedingly commodious engine-house, where all the repairs are intended to be carried on. This structure is in the form of a double parallelogram, the longer one forming the *façade* of the

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building, and the shorter parallelogram being in the same direction and immediately behind. The arrangement of this building appears to be most complete, and is considered to possess many advantages, both in cheapness of construction and convenience, over the polygon buildings, which have been erected on several other lines. By means of a very powerful traversing crane, every part of the workshop is under equal command for the purposes of any description of work connected with the engines; and the forges are detached from the general workshops. The building, when entirely finished, promises to be a complete establishment. At present, the Company are using some temporary buildings about a mile nearer to Romford, for the repairing-shops; and considering the limited room which they here possess, it is surprising to see the perfect order and extreme cleanliness of all the engines on the line.

When speaking of the signals in our last, we forgot to mention, that from these being 100 yards from the station each way, and the man being able to work them without quitting his post at the station, he can lower the signal the moment a coming-in train passes, and be ready to attend to the passengers before the train reaches the station. By this means one man does the duty of two at least, and more efficiently.

(To be continued.)

Public use of Dr. Earle's Process for preserving Timber, &c.

Sir,—The following documents do not require explanation. As they probably will not be without interest to many readers of the Journal of the Franklin Institute, they are offered for insertion, by

Your obedient servant,

Edw. Earle.

Wm. Hamilton, Esq., Actuary.

Ordnance Office,
Washington, Jan. 12, 1843.

Hon. J. C. Spencer, Secretary of War.

Sir,—I have to acknowledge the receipt of a letter from the Hon. R. H. Bayard, of the U. S. Senate, requesting to be informed of "the result of any experiments that may have been made, under the auspices of the Department, in relation to Dr. Edward Earle's method of preserving timber and cordage; together with the opinion of the Department, or of any of its officers, as to its practical value"—the same being referred to this office for a report.

The great cost of gun carriages, and the difficulty of obtaining suitable timber for their construction, induced this office, early in 1840, to consider whether the interests of the service could not be promoted by the adoption of measures to prevent their decay. "Kyanizing," and "Dr. Earle's process," were both duly considered, and the great expense of the former led to the use of the latter, by authority of the Secretary of War. Since the summer of 1840, about 70,000 cubic feet of timber have been cured at the Watervliet arsenal, the greater

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part of which is deposited in store for future use. The exact cost of the operation cannot be stated, but it is believed to be about 3½ cents per cubic foot, and one and a half cents for the use of the patent right.

Sufficient time has not yet elapsed to prove the value of the process by the trials of gun carriages in service; but, during the period of operations, the person charged with supervising the curing of the timber (Mr. R. M. Bouton) has made some experiments, which are set forth in a printed paper published by Dr. Earle, which is hereto appended.

Mr. Bouton is a man possessed of much more science than is usually found in such a first rate practical mechanic, and full reliance may be placed in his statements.

Upon a careful examination of the subject, which its importance to this office, in a pecuniary view, at least, seemed to demand, I have formed the opinion:

1. That the impregnation of timber with the sulphates of iron and copper may be effected by its immersion in a proper solution of those minerals, at a very moderate heat, and with timber of any size, or ength.

2. That timber thus cured will be in a great measure incorruptible, ıree from the attacks of worms, and from dry rot.

3. That its strength is not reduced, and its toughness, or fibrous texture, is improved.

4. That the cheapness of the process, united to its beneficial effects, promises a great reduction in the expenditures for such objects as are susceptible to its use, among which canvas and cordage seem to occupy a prominent place; and, finally,

That this process will furnish the desideratum for the preservation of many things to which it is applicable, and should be patronized by the government.

The letter of Mr. Bayard is returned herewith.

I have the honor to be, sir, very respectfully,

Your ob't serv't,

G. Talcott, Lt. Col. Ord.

(Endorsed)

Navy Department, Jan. 17, 1843.

I unhesitatingly express my full concurrence in the opinion and recommendation of Col. Talcott, within given. I have no doubt that Dr. Earle's process might be advantageously applied to a great variety of materials used in the naval service, and that the saving to the country would be incalculably greater than the cost. I therefore strongly recommend the adoption of Dr. Earle's process, upon such terms as may be considered fair and just between him and the country.

A. P. Upshur

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Bibliographical Notice.

Notice of Liebig's Agricultural Chemistry.

Translated from "Berzelius' Annual Report," by J. C. B. and M. H. B.

At a time when the general agricultural interest has received a great impulse from the excellent work of Liebig on this subject, the following extract from Berzelius' two last annual reports on the progress of chemistry, &c., where he notices this work, may not perhaps be without interest to many of our readers.

"Liebig has, during the last year, published a work entitled 'Organic Chemistry, in its application to Agriculture and Physiology,' to which I wish to direct the attention of chemists. This work treats of subjects which are of the highest interest to agriculture; and I consider it the greatest merit to have brought them forward for consideration, should they even, from the way in which the author disposes of them, have the appearance of being settled with greater certainty than they can be in the present state of our knowledge, and even, sometimes, not be in accordance with what I consider to be most probable. Thus, for instance, Liebig starts from the ideas of Decandotte and Macaire Princeps, of excretions from the roots in the soil, which should be obnoxious, or, at least, useless, to themselves, but available to other plants cultivated in the same soil. But these ideas have afterwards been tested by experiments by Braconnot, distinguished both as a chemist and physiologist, who could discover no such excretions, and showed that, in Macaire's experiments, the water in which the plants were made to grow acts very differently from a soil of the proper degree of moisture. Such ideas, contradicted by experiments, cannot be assumed as correct, and ought certainly not to be given as settled before the objections to them are disproved. Perhaps the latter may be so well founded as to render it necessary to abandon the ideas as incorrect.

"Liebig does not, moreover, consider decaying organic substances in the soil as direct food to the plants; according to him, their food consists of water, carbonic acid, and ammonia, which their parts above the soil take up from the atmosphere, and their roots absorb from the soil, as they are generated by the progressive putrefaction of organic substances, (manure, mould.) As yet, experiments to prove this are entirely wanting, and, even if this should be eventually found to be correct, it would still be too early to assume it as established. But we have a number of experiments showing that the roots take up from the soil such dilute solutions as are contained in it, and it is very natural to imagine that plants should take up such dilute solutions of organic substances, and transform them in their vessels, in the same manner as in the animal kingdom. But, although doubts may thus arise relative to the perfect correctness of several conclusions in this work, no reader will peruse it without clear views

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on many points, of importance in agriculture, of which he may never have thought before."—*Årsberättelse*, 1841, p. 187.

"I mentioned in my last report the ideas of Liebig, according to which, carbonic acid, ammonia, and nitric acid, form the only materials from which plants obtain their elements, and that manures only so far serve as nourishment to them, as they produce these substances, which are the only ones they are capable of assimilating to form their organic constituents. This theory has some foundation in the fact, which has been long known, that plants decompose the carbonic acid of the air, taking up its carbon. How far, on the other hand, ammonia is capable of assisting in the formation of their nitrogen compounds, we know nothing from experiments; hence, it is merely a hypothesis, which abides experimental confirmation. But, as for that part of this theory which holds that water, carbonic acid, and ammonia, (besides nitric acid,) should be the only materials for the formation of plants, it has too much against it, in the common experience of agriculture, to be regarded even as probable."—*Årsberättelse*, 1842, p. 170.

Practical & Theoretical Mechanics & Chemistry.

Theobromin, a New Substance in the Cacao Bean. By J. C. B. *and* M. H. B.

It is generally known that tea and coffee both contain a crystalizable substance, thein and coffein, which are remarkable for their large content of nitrogen, (29 per cent.) for which reason they are supposed to play an important part in the economy of man, where these beverages have come into general use. These two substances were, at the suggestion of Berzelius, identified by Mulder. Woskressensky, (Ann. de Chemie and Pharmacy, XLI, p. 125,) not long ago, discovered a similar substance in the cacao bean, to which he gave the name of theobromin. It is obtained from raw chocolate nuts, by a similar process to that employed for the extraction of coffein from raw coffee. It forms a white crystaline powder, sparingly soluble in cold, more so in boiling, water—the latter becoming opalescent on cooling. It is soluble in alcohol, but less soluble in ether than in water. It does not combine with acids, nor bases, excepting with tannin, an excess of which dissolves it; the combination is soluble in alcohol and boiling water. An alcoholic solution of theobromin yields, with a solution of corrosive sublimate, a white crystaline precipitate, sparingly soluble in water and alcohol. The analysis of theobromin yielded

	By experiment.	Atoms.	By calculation.
Carbon,	46.705	9	46.436
Hydrogen,	4.515	5	4.211
Nitrogen,	35.381	3	35.853
Oxygen,	13.399	2	13.500

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Berzelius expresses its composition by the formula $C^{8} H^{2} N^{2} O^{2} + NH^{3}$, and remarks (*Arsberättelse*, 1842, p. 352,) that its property to be precipitated by tannin and chloride of mercury seems to indicate that it is a vegetable base, and that, notwithstanding the assertion of Woskressensky, of its incapability of combining with acids, a closer study of its properties may prove it to belong, like thein, to that class. It is remarkable that its content of nitrogen is even greater than that of thein, or coffein, which is considered as one of the most nitrogenized compounds among vegetable substances.

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*James Nasmyth's Patent Direct Action Steam Forge Hammer.**

The truly valuable qualities possessed by wrought iron, as the material of all others the best adapted to withstand force, has rendered its use as a mechanical agent almost universal; so important are the purposes it serves in enabling man to combat with the elements, and, as it were, bend them to his will, that we may almost measure the progress of civilization in any nation by the quantity of that inestimable material they convert to their use; hence it is that Great Britain owes no small portion of her power, wealth, and mechanical supremacy, to her superior knowledge of the use and capabilities of this, the most serviceable of all substances.

National improvement is always indicated and accompanied by increased consumption (by reason of increased application) of wrought iron; by its use man first merges from the savage state, and by its extended employment the most civilized nations not only maintain, but advance in, their improvement. It is, perhaps, unnecessary here to remark how entirely we are indebted to wrought iron for the services of the steam engine, and its innumerable progeny of happy results, to say nothing of railways and steam vessels, in the very hulls of which, as well as in other ships, it is rapidly manifesting its superiority over wood, and so giving to the world another magnificent evidence of its all but universality of application. Hence it is that few mechanical improvements are of more real importance than those which relate to the manufacture of wrought iron, not only in respect to its production in the first instance, but also to our increased facilities, and means, of working it into such forms as may be rendered desirable and necessary.

By a property almost peculiar to wrought iron, namely, its all but unmeltableness, its application would have been very limited, by reason of the difficulty we should have experienced in fashioning it into any required form; but by another peculiarity, namely, its capability of being welded, we have the loss of convenience arising from its unmeltableness *more* than made up to us; and where we add to this its extreme malleability, by which property, and by the assistance of heat, it is capable of being forged into any required form, our com-

* The patent right of Nasmyth's Direct Action Steam Hammer, for the United States, is vested in Messrs. MERRICK & TOWNE, Engineers, Southwark Foundry, Philadelphia—who have received full instructions and working drawings from the inventor.

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mand over it is only limited by our means of applying the requisite force, whether by compression, as in the case of the process of rolling, or by blows, as in the case of forging by the hammer; this latter process being by far the most important, not only in respect to its affording us the means of giving to masses of wrought iron the requisite shape and form, but also, when the process of hammering is carried on with due energy, *while the iron is at a welding heat*, the effect of such hammering is productive of a most important improvement in the quality of the iron, as regards its tenacity, and consequent capability of resisting strains without the risk of fracture; this gain of strength arising from the more intimate contact, or union, brought about between the particles of the iron, by reason of the more perfect expulsion of all those impurities which otherwise, by separating the particles, or fibres, of the iron, so impair its strength. Hence we have one of the many important reasons why it is so desirable that we should have the means of hammering iron, when at the proper welding heat, *with all due energy*, whatever be the size, or form, of the mass in question.

The great success which has attended the application of the steam engine in the case of steam ships, and in other instances, has produced a demand for enormous forgings of wrought iron, such as paddle shafts, cranks, &c., that no small difficulty is now felt in the execution of large parts of them, having attained to such a magnitude as to be all but beyond the power and capability of the largest forge hammers to execute them.

The approach of this point of ultimate capability has long been felt, not only by the vast difficulty and expense by the ordinary means, such enormous forgings being so frequently attended by the destruction of the machinery employed, but also by the frequent occurrence of unsoundness being the certain result of inadequate means, and the exceeding the limits and capabilities of the machinery hitherto employed for the purpose, arising from a defect inherent in the principle on which such machinery has been constructed, the evils of which have been rendered more and more apparent by every successive attempt to enlarge the apparatus, with a view to endeavor to enable it to cope with the increase in the magnitude of the forgings it was required to execute.

It was with the view to remove *those defects in the principle* on which such forge hammers were constructed, and to produce such a hammer as should, in the most simple manner, attain all that was desirable in our means of forging the very largest class of work, and that in a manner infinitely more convenient, perfect, and economical, that led me to contrive my *direct action steam hammer*, which I shall now proceed to describe, and which has realized my most sanguine expectations of its advantages.

In order to give such of my readers as are not minutely acquainted with the subject, a more clear view of the advantages possessed by this direct action steam hammer over those of forge hammers of the ordinary construction, I must refer them to Fig. 1, which is intended to represent a forge hammer of the largest class, and, generally, ar-

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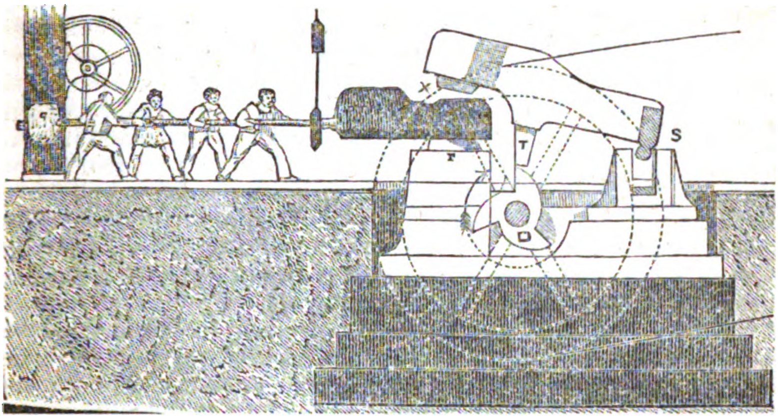
ranged according to the most improved principle. According to the scale on which this sketch is made out, such a hammer would be fully what is called a seven ton hammer, and, consequently, adapted (so far as its principles of construction will permit) for the execution of the largest class of work.

Fig. 1.—View of the Old Tilting Hammer.



One chief and universal feature in all such hammers is, that the power which causes them to rise and fall, and so give out blows on the work on the anvil, consists of *rotary motion*, which, originating in the *rectilinear* motion of the piston of the steam engine, is conveyed to the hammer by, and through, the medium of *revolving shafts*, wheels, &c., and finally re-converted into its original up and down motion by means of the cam wheel, marked D in the sketch; thus, by a very *roundabout* course, we have brought our power back again into the form it first existed, namely, rectilinear motion, or as nearly so as the radial action of the hammer will permit. And what advantage have we obtained by causing our power to travel to its object by such a roundabout course? none that I ever could see; and as to the disadvantages, they are many, and most serious. In the first place, there is great loss of power, on account of the very unfavorable manner in which the momentum of the fly-wheel on the cam shaft D communicates its motion to the helve of the hammer, by a jolting action most unfavorable to the economical communication of power; add to which the vast space of the forge shop, occupied by all the intermediate apparatus of a *complete* steam engine, with its requisite fly-wheels, shafts, beams, and *very costly foundations*, which, in order to endeavor to maintain the apparatus in due order, has to be made of more than ordinary substantiality; so much so, that, to resist the destructive effect of the vibration given to the entire machinery by the action of the hammer, the foundations have to be made so solid as to cost, in some cases, nearly as much as the whole metallic part of the apparatus.

With respect to the action of such a forge hammer, as seen in Fig. 1, it will be found that one grand defect in principle exists,

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namely, that, when engaged in hammering a large piece of work, as that seen in the sketch, by reason of the work occupying the greater part of the clear space between the anvil face and that of the hammer, we have thereby a slight blow when we are doing a large piece of work, and a heavy blow when we are hammering a small, or thinner, piece of work, which is just the very reverse of what we could desire. And, in the execution of large work, this is found to be a most serious evil, inasmuch as, from the nature of the case, we would wish to have the most powerful and energetic blows that it is possible to command. The result of this is, that neither is the mass rendered so sound as we could desire, nor is it brought to its required form except by repeated heatings, at the very great sacrifice of time and iron, in so far as, ere the limited blows of the hammer have produced the required change of form, the welding heat has gone off, and all blows after this tend rather to loosen, than compact, or solidify, the mass. Again, we have another very serious evil, namely, the very confined limits of the space between the hammer face at its highest, and that of the face of the anvil, which renders it quite incapable of admitting, or operating upon, a mass of any great breadth, or height; and besides having the machinery of the hammer quite in the way, in many cases we have also this other disadvantage, namely, that, except for one thickness of work, the hammer face and anvil are not parallel, as will be evident on referring to the sketch, and considering that the face of the hammer acts radial to the centre, S, Fig. 1, in which it rocks. This evil is, to a small extent, obviated by means being given to raise up the tail, or centre, S; but this process is not only difficult, but can only be done between the heats.

With a view to relieve all these defects, I have contrived my direct action steam hammer, which is represented, in one of its many forms and applications, in Fig. 2.

It consists simply of a cylinder, C, turned, as it were, upside down; that is, its piston rod comes out at the bottom of the cylinder, instead of (as in most cases) out of the top; this cylinder is supported over the anvil K by two upright standards, O O, the end of the piston rod being attached to a block, or mass, of cast iron, B, guided in its descent by planed guides, or ribs, cast on the edge of each standard. This block of cast iron is the hammer, or blow-giving part of the apparatus, while the cylinder, with its piston and piston-rod, supplies in the most simple, straightforward, and direct manner, the power by which the striking block, B, is lifted, or raised up. *Gravity* performs the downward action for us in a most *direct* manner. In order to set this steam hammer in action, steam of such a pressure as, operating upon the under side of the piston, will a little* more than balance the weight of the block, B, is conveyed from a suitable boiler, (situated in any convenient part of the premises,) through the pipe, P, into the valve box, in which a slide valve of the most simple form works. The valve, being up, permits the steam to press upon the under side of the piston, and up goes the block, B, *to any height* (within the limits

* About five to six per cent. more pressure than will just balance the block, gives all due activity to the upward, or lifting, action of the block.

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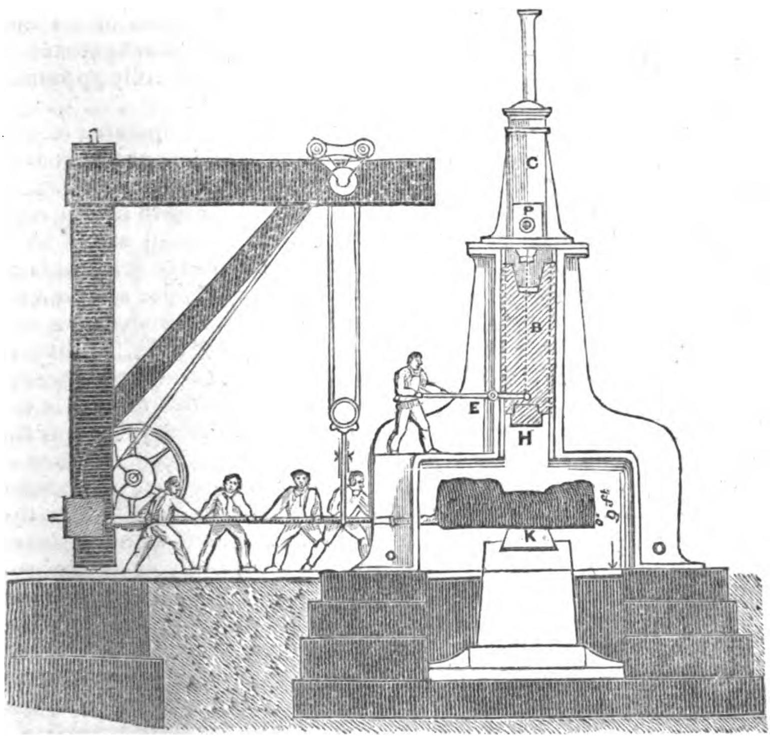
of the length of the cylinder) which the forge man may require. The handle, E, is now moved in the contrary direction, which not only prevents any further admission of steam, but also permits that which had entered to escape by the pipe, L; the instant this is done, the block B descends with all the energy and force due to its weight and the height through which it falls, and discharges *its full and entire* momentum upon the work then on the anvil, with such tremendous effect as to set the blows of all previous hammers at utter defiance! In fact, the power of such a hammer is only limited by the size we please to make it, as *the principle* is capable of being carried out to any extent; whereas, in the case of such hammers as in Fig. 1, they have their limits, by reason of the very mass of material causing them to be weak *per se*, by the intestinal contraction of the iron which composes their mass, and which, in their action, is so destructive and trying to such a form; the consequence is, they generally break over just behind the neck.

Fig. 2.—Nasmyth's Direct Action Steam Hammer.



I have only alluded to the means which this steam hammer gives of obtaining tremendous blows. But, energetic and powerful as it is, it is at the same time one of the most striking examples of the manageability of the power of steam; inasmuch as, when we desire to

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have *any variety* in the intensity of the blow, varying from the most gentle *nut*-cracking tap! to the most awful smash, we have simply to work the valve-handle in proportion, and, by so regulating the *exit* of the steam, we can let down the block, like closing a well-hung window, or *arrest its downward progress in an instant at any part of its stroke*, and retain it there at any required height, for any required time; on the other hand, by duly regulating the entrance of the steam, we can lift the block to any required height from the face of the anvil, or surface of the work, and so regulate the amount, or rapidity, of the blows accordingly.

The form and arrangement of the steam hammer, as given in Fig. 2, is such as present experience shows to be most convenient; according to the scale on which the sketch is made out, the distance between the standards O O gives a clear space of twelve feet, namely, six feet on each side of the centre of the anvil, and six feet height clear over head, as figured in the sketch. But these proportions may of course be varied at will, as the *principle* of this steam hammer affords every facility to extension, or otherwise. The space on each side of the anvil, in front and behind, being quite clear of all machinery, gives every facility to the introduction and management of the work, when we progress, as will be evident to, and fully appreciated by, practical men.

The comparatively small space which the entire apparatus of the steam hammer occupies, may be judged of by a glance at the sketch, Fig. 2, as compared with that of the ordinary construction in Fig. 1. Had I turned the standards in the sketch, Fig. 2, so as to give a *side*, or edge, view, the contrast in respect to space occupied would have been much more striking. As regards the comparative original cost, any one the least accustomed to such matters will at once see the vast advantage, in that respect, in favor of the steam hammer, to say nothing of its vast superiority as to efficiency and little liability to derangement; in fact, so simple is it, that there is scarcely anything to go wrong. One great source of its durability in this respect is the manner in which the mass of the block is raised, namely, through the medium of *the* most elastic of all bodies—steam; which, in place of any destructive jerk, as in the case of motion conveyed by impulse through solid media, so apparent and destructive in its effect in the case of the apparatus of the ordinary forge hammer, with the steam hammer the lifting motion is performed so smoothly as to be absolutely silent in its action, as if the great block had forgot, for the while, that it had any weight at all. I do not intend here to rival the celebrated Caterfelto by wondering at my own wonders! but, truly, the action of this simple, but most powerful, machine is not a little striking, both in its action as well as effect. I think experience will prove that I am not too far yielding to sanguine expectations when I state that the vast facilities which this invention gives to the treatment of large masses of wrought iron, will introduce quite a new era in the manufacture and working of wrought iron. We have now, by means of this steam hammer, a power and capability of producing forgings of wrought iron, of *any* dimensions, whose soundness will

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give the best evidence of the value of the invention in that respect, and from the vast facilities of executing the most ponderous and acquired forms, the saving of time and finish which can be attained under such a hammer, will also prove that a great step has been made in the mechanical arts.

In conclusion, it may perhaps be as well to remark on the valuable and important influence which such a hammer will have upon the quality of iron, as in the case of boiler plates and such like, the quality of which, as regards *soundness,* entirely depends on the efficient manner in which they have been hammered and consolidated in the primary process of faggoting, or shingling, namely, the forming into one perfectly *solid* mass, the block of iron from which such boiler plates, &c., are rolled. Nine-tenths of the defects which are met with in boiler plates, and which have caused such disastrous results, namely, defects from blisters, have arisen from, or may be traced to, imperfect consolidation, resulting from inadequate means of hammering the original mass into a truly solid block, by our not having the *power* to force out all the scoria, which, otherwise, lodging between the pile of pieces of which the faggot is composed, gives rise to the most serious defects, which every practical man has had to deplore. It will, in like manner, be scarcely requisite that I state any of the advantages that will arise in our having, by means of the energetic action of the steam hammer, a perfect security against unsound *anchors,* the importance of which requires no words to set forth. In short, we have now at command an almost new power, inasmuch as, by means of this steam hammer, we have an accession to our means of dealing with power in the form and state of *percussion,* such as has never been attained before, and that in the most *simple,* straightforward, and *effective* manner.

Fig. 3.

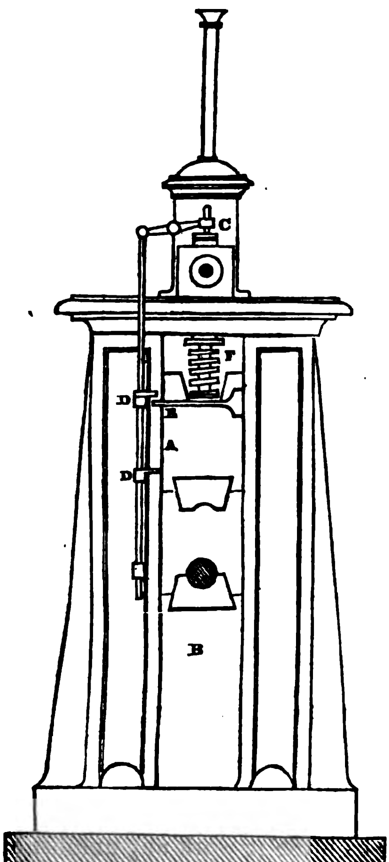

Fig. 3 shows the application of the hammer A for forging an iron shaft laid over the anvil, or block, B, and is made self-acting, as will be seen by a reference to the cut, that when the tappets D D come in contact with the pin, or spring, on the block E, the steam valve C is opened, or closed.

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Fig. 4.

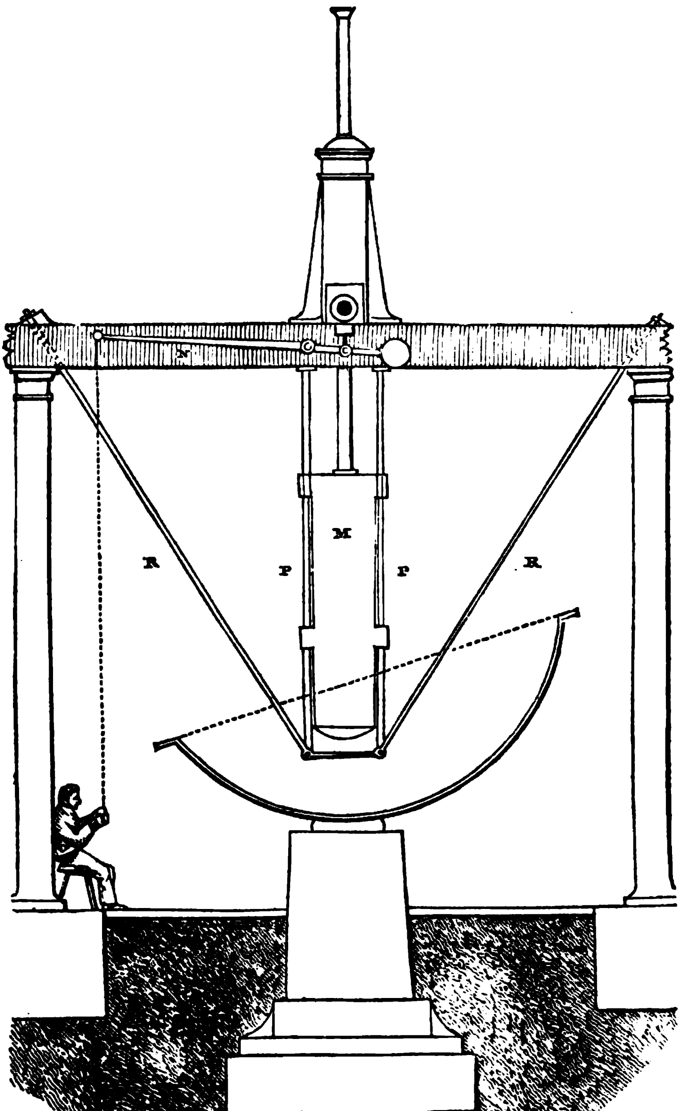

Fig. 4 shows the application of the steam hammer for coppers, pans, &c. The hammer M works in the guides P P, suspended by the rods R to the beam above, like an inverted truss; the action of the man pulling down the lever N opens the valve, so as to admit the steam for raising the piston, and, with it, the hammer.

I may remark, that one boiler can be made to work any number of

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steam hammers, as the steam has only to be conducted to each by pipes, and the power let on and shut off in the same manner as gas; and in most iron forges, the waste heat of the furnace will more than furnish the requisite steam. There are many other applications and details connected with this important invention; but reluctance to further trespass on your readers' attention, and the space of your columns, causes me to defer to a future opportunity.

But I trust the high importance of the subject will plead my excuse for the length to which I have allowed my remarks to extend.

With most sincere respect,

I am, very truly, yours,

JAMES NASMYTH.

Bridgewater Foundry, Patercroft, Jan. 17.

Civ. Eng. and Arch. Jour.

The Practice of Fresco Painting.

(Continued from page 134.)

Methods of Fresco Painting, described by writers on Art.

The observations on the practice of fresco-painting by early writers on art coincide generally with the statements above given; the only point on which those writers do not appear to insist is the necessity of keeping the lime for a very long period. In other respects, Cennini and Leon Battista Alberti, in the fifteenth century; Vasari, Armenini, and Borghini, in the sixteenth century; Andrea Pozzo in the seventeenth; and Palomino in the beginning of the eighteenth, describe, more or less fully, the same process. But before referring to these writers, it may be desirable to take a glance at the ancient authorities who have described the modes of preparing walls with stucco on which fresco-paintings were executed.

Vitruvius suggests that where there is danger of damp affecting the coats of plaster, a thin (brick) wall should be carried up within and in some measure detached from the main wall.* When timber partitions were to be covered with stucco, two layers of split reeds were nailed with broad-headed nails on the upright and cross pieces, the one vertically, the other horizontally; "the double row of reeds thus crossed and firmly fixed prevents all cracks and fissures." The coats of plaster, from the rough-cast to the finished surface, were numerous, namely, after the rough-cast, three of sand and lime, and three of marble-dust and lime. The last coat was often highly polished. "When," Vitruvius afterwards observes, "only one coat of sand and lime and one of marble-dust and lime are used, the plaster is easily broken and cannot receive a brilliant polish." When frescos were added, the surface was necessarily somewhat less smooth.

The passage that follows, relating to paintings on walls, has been

* De Architect, l 7, c. 4. This is the mode in which the stuccoed and painted walls of Pompeii are constructed; the bricks, or rather tiles, are placed edgewise, and are connected by leaden cramps to the brick or tufo wall, without being in immediate contact with it.

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often the subject of controversy, but when compared with the practical details of fresco, already described, it can hardly fail to be understood as referring to that method. The ancient writer's mode of accounting for certain effects is, of course, unimportant. "Colors," Vitruvius observes, "when carefully applied on moist stucco, do not therefore fade, but (on the contrary) last forever; because the same having been deprived of moisture in the kiln, and having become porous and absorbent, readily imbibes whatever (moisture) comes in contact with it; and the whole, when dry, seems composed of one and the same substance and quality. Hence stuccoed walls, when well executed, do not easily become dirty, nor do they lose their colors when they require to be washed, unless the painting was carelessly done, or executed after the surface was dry." The general evenness of the wall is here explained to be essential to the due effect of the paintings: the opposite evil, that of an undulating surface, on which dust lodges irregularly, is seen in some of the frescos of the Vatican.

This general evenness of the plaster does not suppose unpleasant smoothness of surface in the fresco; in many Italian, and indeed many antique, mural paintings, the traces of the brush often indicate a considerable body of color; but care seems to have been taken not to load the surface unequally. In a London atmosphere this comparative evenness of the surface might, on the Vitruvian principle, protect the painting longer from smoke and dust, while it would assist the operation of cleaning. But the work might be protected by other means; the plaster might be applied so that the face of the wall—at least in the portions intended to receive frescos—should not be quite perpendicular, but incline a little inwards (with reference to the room) towards the upper part. In connexion with the question of surface, it may be remarked that the hardening of the lime takes place sooner in proportion to the roughness of the surface. In plate 2 of Smith's translation of Vicat ("Résumé sur les Mortiers et Ciments Calcaires") will be found representations of sections of lime a year old, exhibiting the progress of the carbonic acid and the comparative redintegration of the original carbonate of lime. Captain Smith remarks (p. 173) "It would be difficult to credit, did we not see it, how great an obstacle a smoothness of surface presents to the penetration of the carbonic acid."

Leon Battista Alberti copies Vitruvius in many points: he observes generally that the more coats a wall receives the better the surface may be polished, and the longer it will last, and speaks of ancient examples in which there were nine successive coats. He alludes more directly to the practice of his own time when he says that no stucco should be composed of less than three coats:* these he afterwards describes. "The first rough coat," he observes, "should

* He is still so far true to the Vitruvian rules, that he speaks of each layer in the plural, as if the number of coats was indefinite. His Italian translator (Cosimo Bartoli, 1550,) reduces these half classical directions to the practices of the day, and gives the Florentine technical terms for the general expressions of Alberti; the *rinzaffato* rough-coat, the *arriciato* sand coat, and the *intonaco* (tunica) fine plaster.

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be composed of pit sand and pounded bricks; the pieces of brick should not be broken too small. For the second coat river sand is best adapted, and is less apt to crack; this second coat also should be somewhat rough, because nothing that is applied to a smooth surface will adhere to it. The last coat should be as white as marble, in fact pounded white marble should be used instead of sand. This coat need not be thicker than half a finger's breadth, some make it no thicker than the sole of a shoe. In many places," he proceeds, "we find nails fastened in the wall to keep on the coats of plaster, and time has shown that they had better be of bronze than of iron. Instead of nails, I much approve the practice of inserting thin pieces of flint, projecting edgewise from the joints of the stone; these should be driven in with a wooden mallet." Various directions follow, partly derived from Vitruvius, partly from his own experience. Speaking of colors that are fit and unfit for fresco, his expressions are at once in accordance with an ancient authority,* and with modern practice; in this as in other instances Leon Battista Alberti appears as the connecting link between ancient and revived art. He speaks of the "newly-invented art of painting with linseed oil," as calculated to last for ever on walls, provided they are perfectly free from damp; on this subject he could of course have no experience. He concludes by observing that he had seen even fresh lime painted with colors prepared from vitrified substances. Cennini, who has recorded the old Florentine methods, states that "both the lime and the sand should be well sifted. If the lime is what is called a rich lime, and has been recently slaked, there should be two parts of sand to one of lime.† On being slaked it should be well mixed and stirred, and a quantity should be made, sufficient to last for 15 or 20 days. It should then be suffered to remain *for some days*, in order to render it less caustic, for if too caustic, the *intonaco*‡ will blister." The mortar composed as above serves for the first coat, the surface,

* Pliny (l. 35, c. 7) observes that certain colors, which he enumerates, are unfit for fresco (udo), but may be employed on a dry ground of gypsum (cretulam). So elsewhere (l. 33. c. 13) speaking of an artificial blue, he states that it would not stand on lime, "usus in cretâ, calcis impatiens." Andrea Pozzo observes that all colors may be used on a ground of gypsum; the word creta or its diminutive is probably to be understood here to mean gypsum; the similar Italian word is often employed in this sense. Sir Humphrey Davy observes, "the ancients were not acquainted with the distinction between aluminous and calcareous earths, and 'creta' was a term applied to every white fine earthy powder." (Philosophical Transactions for 1815, p. 112, note.) The precise meaning of creta is, however, here less important; the above passages of Pliny, together with that before quoted from Vitruvius, are sufficient to establish the fact that the ancients painted on moist lime. The analysis of some antique paintings by Sir H. Davy, confirms this.

† This is the general proportion mentioned by the ancient writers, (Cato, Vitruvius, Pliny, and Palladius,) and appears to be now commonly in use. According to some modern authorities, the proportion of sand (for general purposes) may be very much increased with advantage; see Higgins, 'Experiments and observations made with the view of improving the art of composing calcareous cements, &c., London, 1780," p. 51. But Vicat, by a series of accurate experiments, ascertained that "the resistance of mortars made from very rich limes slaked by the ordinary process, increases from 50 to 240 parts of sand to 100 of lime in stiff paste, and beyond that decreases indefinitely." (Résumé sur les Mortiers et Ciments Calcaires, p. 51.) Thus two parts and half of sand to one of rich lime are already beyond the due proportion.

‡ Cennini mentions two coats only, and applies the term *intonaco* to both.

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of which is to be left somewhat rough; the application of the thinner coat or painting-ground is afterwards described, and the lime for this purpose is recommended to be well stirred and manipulated, "till it appears like ointment." The practice of painting, described by Cennini, is less important, but the allusion to glazing in fresco is worth consulting." The mode of preparing lime for the white to be used in painting, called "bianco sangiovanni," is precisely the same as that practised by modern fresco painters, and is thus described by Cennini. "Take very white slaked lime reduced to a fine powder; place it in a large tub, and mix well with water, pouring off the water as the lime settles, and adding fresh for eight days. The lime, divided into small cakes, is then placed to dry in the sun on the house-top, and the longer these cakes are left the whiter they become. To shorten the process, the cakes may be moistened again with water and well ground, and then again dried; this operation, once or twice repeated, renders the lime perfectly white." Cennini adds, "without this finely-ground white, flesh-tints and other mixed tones that may be required, cannot be executed in fresco."

Armenini describes some varieties of this process as follows:—"Take the whitest lime, such as is commonly found in Genoa, Milan, or Ravenna; this is to be well washed (purgata) before it is used; the painters prepare it in various ways; some, in order to render the lime less caustic, boil a certain quantity well on the fire, always skimming the froth; it is then suffered to cool and settle in the open air; the water is poured off, and the lime is put on new sun-baked bricks [which absorb the moisture]; and the lighter the lime the purer it is. Others bury the lime in the earth after having thus washed it, and keep it in this state many years before they use it; others expose it while undergoing the same preparation, on the roofs of houses. Some mix it in equal proportions with marble dust. But it has been found that if the lime is exposed to the air in a large vessel, and water that has been boiled is poured on it, the whole being stirred, and if the next day it is spread in the sun, it will be sufficiently purified, and may be used for painting the following day, but not for flesh-tints, for these might undergo some change at the edges (of the successive patches of plaster)."*

Speaking of retouching, Armenini observes, "in frescos which are not exposed to the weather, it is possible to give the requisite completeness by going over the work when dry." The shadows, he adds, may be finished and deepened, "by hatching, as in a drawing, with black and lake, in water-colors, using a brush of marten-hair, not too small. In diluting the colors, some use gum, some thin size, some tempera (white and yolk of egg).† He admits that in the course of time such retouchings fade.

* Director Cornelius, in addition to his opinions already given on this subject, thus expresses himself in answer to some further inquiries:—"All lime used for the first and second coats on the wall should be old, having been preserved in pits. That lime only is boiled which is used as a pigment."

† This is explained in 1. 2, c. 8 (on Tempera). "The colors are commonly mixed with thin size. and also with tempera, except the blues, which would become green, owing to the yellowness of the egg medium." It appears from Cennini (ib. p. 70,) that the yolk of egg

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The descriptions of Vasari and Borghini are more concise. It might be inferred that a mixture of a certain quantity of sand with the lime must reduce the whiteness of the latter to a middle tint, but Borghini alone takes notice of this circumstance; he even assumes that a slight tint of black is added to the plaster, perhaps when the sand was of too warm a color. From the description of Leon Battista Alberti, it appears that the last coat was white, and the mixture of lime and marble-dust, mentioned by Armenini, seems to show that the same practice was sometimes followed in the 16th century. Armenini speaks also of another practice which agrees with the appearance which some of the older frescos present; he says that some painters were in the habit of covering the wall with a coat or two of white (wash) immediately before beginning, in order to give more brilliancy to the superadded colors. He disapproves of the practice, as tending to injure the effect of the shadows, but the practice itself shows that in this case the *intonaco* was not in the first instance white.

Andrea Pozzo, the author of the original of the Jesuit's Perspective, and the painter of the celebrated ceiling of S. Ignazio in Rome, and other works of the kind, added a short treatise on Fresco to his great work on Perspective.* The subject is treated under the following heads:—1. The construction of the scaffolding. 2. The application of the rough-cast (*arriccaire*): on this he observes, that the painter should never begin to work where the rough-cast has been recently laid on, especially if in interiors, on account of the moist exhalations and the smell of the lime, both of which are hurtful.† 3. The application of the *intonaco*. This is to be done when the wall is thoroughly dry; it is then well moistened as before described before the *intonaco* is laid on. "The lime used for this purpose should have been slaked *a year or six months* before, and is mixed with well-washed river sand of moderate fineness. In Rome, the painters use pozzolana, but as this is of unequal grain, it is difficult to levigate mortar composed of it, and it is impossible to stir it again after some hours; this being sometimes necessary. An expert and active mason should be selected to spread the *intonaco* equally, and to leave the painter time enough for his work within the day. 4. Roughening the surface (*granire*). The *intonaco* being equally spread, it will be well slightly to rub up with a brush the minute grains of sand, as the colors adhere better to a somewhat rough surface. This operation is essential in great works that are to be seen at a distance; it is also useful in a certain degree in near works, but

was used with the white, and even alone; the white alone was sure to crack. Armenini further observes, "the Flemish artists use size alone, because tempera has the effect of darkening the colors." The vehicles of gum, size, vinegar, and white or yolk of egg used by the moderns for tempera (or for retouching frescos), were all employed by the ancients. See Pliny, 1. 35, c. 6.

* At the end of the first edition, 1693—1700. The first section, on the construction of the scaffolding, consists only of a general recommendation to attend to safety, but the work on Perspective contains some interesting descriptions of his mechanical contrivances in the execution of the extensive works in which he was engaged.

† It is evident, however, that, to avoid these evils, a month or two would be sufficient.

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it will be advisable in the latter case to spread a sheet of paper over the work at last, and with the trowel slightly to press the surface; the too prominent particles of sand will then sink in and disappear. 5. Drawing. Every one knows that before beginning to paint it is necessary to prepare a drawing and well-studied colored sketch, both of which are to be kept at hand in painting the fresco, so as not to have any other thought than that of the execution. There should also be a cartoon, of the size of the intended work; this may be placed in the situation in order to judge of the effect at a distance, and to make such corrections as appear necessary." 6. Enlarging and transferring by squares. Such methods are recommended for curved and irregular portions of architecture where it may be difficult to trace from drawings. According to some passages in Cennini and Armenini, this seems to have been the practice with the early Florentines even on level walls; in this mode the squares were first marked on the rough dry mortar and repeated, (the extremities of the lines being visible on the *intonaco*). In this process time was lost, and the outline was less correct. 7. Tracing on the wall. Either with an iron point or by pouncing a pricked outline as before described. 8. The Palette. "Before beginning to paint, the colors are to be prepared as well as the intermediate tints, such at least as are wanted for one figure; indeed, if a mass of architecture is to be painted, it will be necessary to prepare a key-tint for the whole work, otherwise it will be found difficult in repeated operations (after the tints have changed in drying) to match the color. Other methods, however necessary, need not be described, as they are common to oil-painting." 9. Painting. The general observations are the same as those before given; the author suggests that a small (tin) vessel for water may be attached to the palette; he recommends not beginning to paint till the *intonaco* will barely receive the impression of the finger, otherwise the whole work will be weak, and could only serve for a first painting. 10. Painting more solidly (*impastare e caricare*). "This is peculiar to fresco, that the first colors which touch the lime immediately lose their force. It is therefore necessary to go over the work again with a greater body of color, taking care never to leave the portion allotted for the day till it is quite finished, because all retouching after a certain time will deform the work: it would be better to wait even till the wall is quite dry, and then retouch." 11. Retouching. The author admits that it is better not to retouch, but adds that as the lime always undergoes some slight change, particularly in the shadows, it is sometimes unavoidable; he observes, that such retouchings are useless in the open air, as the rain washes them away. 12. Softening. He recommends the use of soft, long brushes, not too moist, and states that the finger may be used sometimes with effect in heads when the lime begins to grow hard. He alludes to other methods for the gradation of light in glories, &c. 13. Excision and entire repainting. The possibility of such corrections, and the mode of making them, have been already alluded to. "In interiors, alterations may be made merely by repainting on the dry surface, provided such alterations are required for distant figures." 14. Coloring. General

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observations on colors fit for fresco. 15. White. Lime kept a year or six months is to be thinned in water, and passed through a hair-sieve into a large vessel; the water is poured off as soon as the lime has settled: thus prepared, it is fit for painting. A list of colors follows, differing but little from that given by the older writers, and also by Prof. Hess, Director Cornelius, and Mr. Andrew Wilson. The following is Pozzo's method of preparing vermilion for fresco. "This color is altogether hostile to lime, particularly when exposed to the external air, but I have often used it for draperies in paintings executed in interiors, having first prepared it as follows:—Take pure vermilion in powder, and having placed it in an earthenware vase, pour on it the water that boils up when lime is slaked in it; the water, which should be as pure as it can be, is then poured off, and the operation is often repeated. In this manner the vermilion is penetrated with the quality of the lime, and always retains it." Cennini and Armenini, on the other hand, distinctly say that vermilion will not stand in fresco.

Palomino, in his first general account of fresco, gives a list of the principal works in that method executed by the Spanish masters in Madrid, Cordova, and Seville. His description of the method itself is fuller than those hitherto referred to in this paper; but, to avoid unnecessary repetition, it will be sufficient to quote his directions where they differ from those already given. The lime should, he says, be prepared, *if possible, four or six months* before it is used. Then, after having been passed through a hair-sieve, it is mixed with sand, quite free from clay, sifted in like manner; his directions for doing this are minute. The quantities are to be *equal*, this he had found from his own experience to be the best proportion, especially if the lime is rather fresh, but if not, the plaster may be composed of three parts of lime to two of sand. This stucco is to be kept in a large tub, in which it may be conveniently stirred; it is to be kept quite moist, and remains covered with water. If the work to be executed is extensive, it will be well to prepare more than one tub; thus while the first is being used, the additional provision may be duly tempered. In this state it is to be stirred and beaten daily, taking care to remove the pellicle which remains on the surface of the water; thus prepared, it becomes perfectly mild and of the consistence of lard, it no longer injures the colors, nor, in passing from the wet to the dry state, is it liable to those changes which sometimes disappoint the most expert. "Three things are essential in the rough-cast before applying this *intonaco;* first, that it should be perfectly dry, otherwise saltpetre will appear; next, that it should be generally level though rough, for if not the *intonaco* will be unequally thick, and will crack where it is thickest; thirdly, that it should be well wetted before applying the *intonaco.*" The author even recommends wetting the portion to be painted, the evening before, especially in summer. "The *intonaco* should be about the thickness of a dollar.* After it is well spread, the assistant is to go over it with a roll of soft, wet linen, to get rid of the extreme smoothness, to remove the traces of

* The particular coin mentioned is the "real de à ocho."

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the trowel, and slightly to stir the sand. The surface is next to be lightly passed over with a handkerchief to remove the particles of sand which are on the surface, and which, in painting ceilings," the author observes, "might get into the eyes. Care must be taken in tracing the first portion of the composition, to fix the paper precisely in the right place, because the subsequent lines depend on the first; for this purpose, the whole drawing had better be first fitted to the space before it is cut up for the convenience of tracing." The drawing—in this instance a picked outline—is pounced with a bag of pounded charcoal; the edge of the portion first applied should also be pounced as a guide where to cut off the superfluous *intonaco:* it is, however, cut away not close to the lines so marked, but about two fingers' breadth from it, to avoid cracks and to ensure the completion of the portion traced to the very edge; (the remainder of the superfluous *intonaco* is not to be scraped away till the day's work is done.) The dotted outline left by the pouncing is then to be gone over with black chalk, which will at once leave a dark line, and at the same time slightly indent the surface; so that if, in painting, the chalk line should disappear, the indented one will still serve as a guide. In describing this method, the author alludes to the old method of tracing with a wooden point, and alludes to frescos thus drawn in the Palace del Pardo. He speaks of the finished cartoons of Michael Angelo, Raphael, the Carracci, and others, but observes (and here the degeneracy of his age appears), that since their time artists had become impatient of so much toil, having found that their enthusiasm evaporated before the period arrived for the execution of the painting.

The surface is now to be again lightly wiped with a handkerchief to remove the charcoal that might remain; it is then to be sprinkled with water with a plasterer's large brush; this and a vessel of clean water are to be kept at hand, as the same operation may require to be often repeated, especially in summer. Another brush and a separate vessel of water should be kept for washing out any work which may require to be effaced; the water in this second vessel becomes gradually tinged with lime, and cannot serve for sprinkling the work as it would leave white spots. In frosty weather it is necessary to keep these vessels on the fire, and the assistant should use warm water in first preparing the wall. "If," the author continues, "owing to extreme cold, the surface of the *intonaco* freezes, the effect is worse than rapid drying, for no absorption takes place, and the colors afterwards crumble off like ashes, as I have myself experienced. If, therefore, the use of warm water is not sufficient to prevent such effects, it will be better to wait for milder weather." The list of colors does not materially differ from those already given, but the qualities and changes of the various pigments in fresco and the best modes of employing them are minutely described. Vermilion, the author says, will stand if passed over terra rossa. The preparation of the lime for mixing with the colors is the same as that already mentioned; the composition of the principal tints and their preparation immediately before employing them, are described.

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A close, silk sieve is recommended in preparing the white for the palette. If the lime be too fresh, its causticity may be reduced by mixing finely-ground marble dust with it. A large palette of well-prepared *canvas* is proposed on account of its lightness; the palette is cleaned from time to time with a sponge. In the execution, the back ground and more distant portions of the work allotted for the day are to be put in first; the observations on these practical details are copious and useful; the tints may be softened, if desired, so as to equal the union of oil-painting by means of a moderately moistened brush.

For retouching, the author recommends goats' milk or common milk thinned with water, and mentions some colors that may be employed:* Luca Giordano, he adds, retouched with white of egg. It appears from the author's experience (and this is confirmed by modern practice), that retouchings are most necessary at the junctions of the successive patches of the *intonaco.*

The author remarks that the old masters went over the *intonaco* with a general tint of white and terra rossa before they began to paint, to render the surface more even; the operation, before described, of pressing and smoothing the surface by means of paper, was, he states, practised by them at last, when the day's work was quite completed. He concludes with some observations of cupola-painting, and on the constructions of scaffoldings.

From the report of Cavaliere Agricola on Raphael's frescos in the Vatican, it appears that the effect of those paintings was originally much heightened by retouching, some of which have faded. Thus in the architecture of the "School of Athens," the masses of light and dark only were put in fresco, but the minuter forms and mouldings were added in water-colors when the fresco was dry: a similar double operation is observable in white draperies.† In some instances even colored retouchings are apparent; these are introduced in the mode described by Armenini, not in masses, but by means of hatching (employing lines as in shading a drawing); one of the cardinals in the subject of "Attila" is thus finished. Such retouchings appear to be distinct from those added by Carlo Maratti. Lond. Athenæum.

Qualities of Iron and Steel.

At a late meeting of the Geological and Polytechnic Society of Yorkshire, the Rev. Dr. Scoresby read a paper on "A Practical Method of Determining the Qualities of Iron and Steel." The lecturer observed that the principle which he had to submit to them bore on

* Some blues are best added when the wall is dry; thus it is related that when the Pope compelled Michael Angelo to remove the scaffolding from the Capella Sistina, the retouching of ultramarine had not been added. See Condivi, Vita di Michaelangelo.

† These methods appear to have been the remains of the early Florentine practice. Cennini says, "Every thing which is executed in fresco requires to be finished and retouched when dry in tempera." (Ib. p. 74, and note.) The frescos of the early Italian painters were in fact half tempera-paintings. Merimée (De la Peinture à l'Huile, p. 310) appears to be in error in supposing that Cennini directs certain colors to be mixed with tempera when used on the wet lime. The Italian artists, no doubt, alluded to the second operation.

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the determination of the different qualities of the different numbers, or kinds, of cast-iron and malleable iron as produced from our different ores in this neighborhood. In order, however, to render the subject intelligible, and the process satisfactory, he thought it would be useful to develope, in the outset, the principles upon which the mode of determining the qualities of the different substances was founded; for the methods of inductive science required that they should, at all events, be enabled to see some relation between the cause and the effect, the means and the end. After stating some particulars with respect to the nature of the magnetic power on which the determination depended, he proceeded to enumerate the foundation principle in his processes for determining the quality of iron—that whereas ferruginous substances generally were capable of the magnetic condition, those most perfectly ferruginous, or of the purest iron, were capable of the highest development of magnetic condition. If he brought a piece of cast-iron to the magnet, it would be found that it exhibited the magnetic character in a much inferior degree to that which malleable iron did. He might show that a piece of steel would exhibit it, by mere contact, in a slighter degree than iron. (Dr. Scoresby took a piece of steel and placed it beside the magnet, after which it suspended a small key.) There was there a less tendency to get magnetism by juxta-position than in iron, but there was a greater tendency to retain it; for whilst the iron lost its power by removal from the magnet, the steel did not. The more imperfect the iron, as in ores having perhaps one-third, or two-thirds, or five-sixths, of earthy substance—the more it was in a state of oxide—the less were its capabilities for showing the magnetic action. If they took cast-iron they would find a susceptibility of the magnetic influence, but in a degree of capability very different from that of malleable iron. If they took malleable iron, of a quality pure and soft, they would find the highest capacity for the magnetic condition. Now, when he discovered that any portion of ferruginous substance in a body rendered that substance capable of magnetic development, and when he knew that malleable iron generally exhibited that in the highest degree, then he drew the inference, that that which was most perfectly iron would show the highest development of the magnetic condition; and, therefore, that the iron which should exhibit the highest magnetical capabilities would be the best quality of iron. There were two methods by which, on these principles, they might determine the quality. (The Rev. gentleman then placed upon a stand a magnetic needle, or compass, having at the end a small graduated card as a scale. He then took up a small flat magnet and two small flat pieces of iron.) He had there two pieces of iron from the Bowling works; they were marked B and L, B being the mark for the best iron, and L iron of the lowest quality. He had also a superior steel magnet of the same size. (He then opposed the magnetic steel bar to the compass at some distance, and placing in succession upon it the iron plates B and L, he found that the needle receded from the magnetic iron with L upon it further than from B, though placed at equal distances.) Thus, upon the principle that he had asserted, the B

iron, which fetched the highest price in the market, and which cost more in the manufacturing, appeared, from its greater neutralizing effect on the magnet, to be a more perfect quality of iron, to have less crude matter in it, or to be more purely ferruginous than the other. For, just as he had anticipated, the bar B proved to have higher capabilities of magnetic influence than the bar L. In order to ascertain this more conclusively, he had got half a dozen plates of each kind of iron made, in order to get a mean result, which would be more accurate than that obtained from a single specimen.

To illustrate his method of determining the capacity of the several plates of iron for magnetism, as shown by their respective neutralizing action on the steel magnet of like dimensions, the Rev. gentleman showed that the action of the magnet alone upon the compass, at the distance of fifteen inches, produced a deviation in the needle from the proper meridian of about 20 deg., or two such magnets together of 31 deg. 15 min. Having, with the series of iron plates kindly furnished him by the managers of the Bowling Works, placed each of them in succession betwixt a pair of small magnetic steel plates, he found the average effect at the same precise distance to be, that the plate L reduced the action of the magnets on the compass to 8 deg. 2 min., and the plate B to 6 deg. 45 min., so that the mean reduction of power (the measure of the magnetic capacity) by L was 31 deg. 15 min—8 deg. 25 min.=22 deg. 50 min., and by B. was 31 deg. 15 min.—6 deg. 45 min.=24 deg. 30 min. Thus showing that the best iron had decidedly the highest magnetic capacity, and that the magnetic capacity of each kind had an analogous relation to the respective values of these two articles in commerce. Dr. Scoresby then went on, by the application of another principle, to investigate the quality of cast iron. For that purpose he had obtained six or seven sets of the same size of the two extreme qualities. One consisted of the best quality of cast-iron, the other was of inferior quality. They were of the qualities usually marked 1 and 3. There might be a considerable variety in No. 1 and 3; but the difference between 1 and 3 was sufficiently characteristic. There was also a considerable difference betwixt the two classes in price, as well as quality. No. 1 had less oxygen and a larger portion of carbon than No. 3, being of a purer description. Without going particularly into the chemical constituents of iron, he might just observe, that as the best quality of iron had, in the other case, the highest magnetic principle, he expected he should, in this case of cast-iron, find a similar law. He treated it, however, in a different manner. He got the plates cast in the same way, in "green sand," so that they should be very hard, and might exhibit more of the nature of steel. His plan was to try them by magnetizing them and converting them into real magnets, being of opinion that as the best steel produced the best magnets, so the best cast-iron would produce the best magnets. His first experiment was by magnetising them separately, and then carefully trying their powers by the compass. One kind, No. 1, had the power of causing the compass to diverge, on an average, 13 deg. 41 min., while No. 3 only caused it to diverge 13 deg. 7 min.—the dif-

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ference between the two being as 136 to 100. Thus it appeared that the best iron had a power about one-third greater than the power of the inferior. But he tried it another way. Having found that the accumulating magnetic capabilities of substances, in relation to their number, became another test of quality, he began to try them one upon another, taking the exact quantity the compass diverged after each addition. He put a second of the best quality, and found that the divergence of the compass was about 18 deg., while No. 3 was only 12 deg. 30 min. Six plates of the best cast-iron thus combined, produced a deviation of 25 deg. 47 min., while the inferior only produced a deviation of 17 deg. 44 min., being 8 deg. less than the deviations of the best series. He did not mean to say that the theory was established on which this principle of testing cast-iron was founded; it would require many more experiments; but yet, so far as his experiments had gone, the object he had in view was fully realized, for it had been shown that they could detect quality by a scientific mode, without breaking into metal—they could discern the different qualities, in the kinds he had compared, to a nicety, equal to that which would be shown by weighing 15s. in gold, and a sovereign. The lecturer next proceeded to the application of the principle to the determining of the quality of steel. With regard to wrought-iron, it had been shown to have no permanent capabilities for retaining magnetic influence; it retained it so little that its retentiveness afforded no practical test of quality. When they tried steel, however, they found a certain permanency—no matter what might be the condition or quality of the steel, whether hard or soft, good or bad, it was capable of permanent magnetism. (He then took up two pieces of steel.) He had there a piece of steel of a very fine quality and very soft; he had given it the magnetic power. He had also another piece of steel of like quality but perfectly hard, and it was also a magnet. Now herein steel exhibited a peculiar difference from iron in its magnetic properties. Iron was capable of more magnetism when it was in contact with a magnet; but steel retained it on its removal from the magnet, whilst iron lost it. If iron would not retain the magnetic influence while steel would, he first came to this conclusion, that that which was most perfectly steel would retain the most power (that is in like condition of hardness), and that that which had the least carbonaceous matter in it would be the least permanent. (Dr. Scoresby illustrated this principle by many experiments, and then proceeded to explain his process for the determination of the hardness and temper of steel). He stated that the principle had long been held, that the harder the steel the more permanent the magnet. The truth of this he had tried in many experiments, and had always found it so. And now he came to the practical rule for knowing the hardness by the magnetic tenacity. If it was true that the hardest steel made the most permanent magnets, then it was only necessary to obtain a knowledge of the degree of permanency as the measure of the hardness.—[He then magnetised two needles of similar quality, but different in hardness, and compared the weights which they respectively bore after being subjected to the action of

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the test-bar—when one had lost a little, the other the whole.]—Hence, he came to this conclusion, that the former was the hardest; which, on trial by other means, was proved to be the fact. He then applied the test of the deviation of the compass, and showed also, by this means, that the hardness of the steel might be discovered with great minuteness; so that, of 100 bars, or plates, of the same kind, as to quality, they could easily be arranged in the order of their respective degree of hardness. Mining Jour.

On Thermography, or the Art of Copying Engravings, or any Printed Characters, from Paper, on Metal Plates; and on the recent Discovery of Moser, relative to the formation of Images in the Dark. By ROBERT HUNT, *Secretary of the Royal Cornwall Polytechnic Society.*

The Journal of the Academy of Sciences of Paris, for the 18th of July, 1842, contains a communication, made by M. Regnault, from M. Moser, of Königsberg, "Sur la formation des images Daguerriennes," in which he announces the fact, that, "*when two bodies are sufficiently near, they impress their images upon each other.*" The Journal of the 29th of August contains a second communication from M. Moser, in which the results of his researches are summed up in twenty-six paragraphs. From these I select the following, which alone are to be considered on the present occasion.

"9. All bodies radiate light, even in complete darkness.

"10. This light does not appear to be allied to phosphorescence, for there is no difference perceived, whether the bodies have been long in the dark, or whether they have been just exposed to daylight, or even to direct solar light.

"10. Two bodies constantly impress their images on each other, even in complete darkness.

"14. However, for the image to be appreciable, it is necessary, because of the divergence of the rays, that the distance of the bodies should not be very considerable.

"15. To render the image visible, the vapor of water, mercury, iodine, &c., may be used.

"17. There exists *latent light*, as well as latent heat."

The announcement, at the last meeting of the British Association, of these discoveries, naturally excited a more than ordinary degree of interest. A discovery of this kind, changing, as it does, the features, not only of the theories of light adopted by philosophers, but also the commonly received opinions of mankind, was more calculated to awaken attention than any thing which has been brought before the public since the publication of Daguerre's beautiful photographic process. Having instituted a series of experiments, the results of which appear to prove that these phenomena are not produced by *latent light*, I am desirous of recording them.

I would not be understood as denying the absorption of light by bodies; of this I think we have abundant proof, and it is a matter

well deserving attention. If we pluck a Nasturtion when the sun is shining brightly on the flower, and carry it into a dark room, we shall still be enabled to see it by the light which it emits.

The human hand will sometimes exhibit the same phenomenon, and many other instances might be adduced in proof of the absorption of light, and, I believe, indeed, of the principle that light is latent in bodies. I have only to show that the conclusions of M. Moser have been formed somewhat hastily, being led, no doubt, by the striking similarity which exists between the effects produced on the Daguerreotype plates, under the influence of light, and by the juxtaposition of bodies in the dark, to consider them as the work of the same element.

1. Dr. Draper, in the Philosophical Magazine for September, 1840, mentions a fact which has been long known, "That if a piece of very *cold* clear glass, or, what is better, a *cold*, polished, metallic reflector, has a little object, such as a piece of metal, laid on it, and the surface be breathed over once, the object being then carefully removed, as often as you breathe again on the surface, a spectral image of it may be seen, and this singular phenomenon may be exhibited for many days after the first trial is made." Several other similar experiments are mentioned, all of them going to show that some mysterious molecular change has taken place on the metallic surface, which occasions it to condense vapors unequally

2. On repeating this simple experiment, I find that it is necessary, for the production of a good effect, to use dissimilar metals; for instance, a piece of gold, or platina, on a plate of copper, or of silver, will make a very decided image; whereas copper, or silver, on their respective plates, gives but a very faint one; and bodies which are bad conductors of heat, placed on good conductors, make decidedly the strongest impressions when thus treated.

3. I placed upon a well-polished copper plate, a sovereign, a shilling, a large silver medal, and a penny. The plate was gently warmed by passing a spirit lamp along its under surface; when cold, the plate was exposed to the vapor of mercury; each piece had made its impression, but those made by the gold and the large medal were most distinct; not only was the disk marked, but the lettering on each was copied.

4. A bronze medal was supported upon slips of wood, placed on the copper, one-eighth of an inch above the plate. After mercurialization, the space the medal covered was well-marked, and for a considerable distance around the mercury was unequally deposited, giving a shaded border to the image; the spaces touched by the [mercury?] were thickly covered with the vapor.

5. The above coins and medals were all placed on the plate, and it was made too hot to be handled, and allowed to cool without their being removed; impressions were made on the plate in the following order of intensity,—gold, silver, bronze, copper. The mass of the metal was found to influence materially the result; a large piece of copper making a better image than a small piece of silver. When this plate was exposed to vapor, the results were as before (3,

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4.) On rubbing off the vapor, it was found that the gold and silver had made permanent impressions on the copper.

6. The above being repeated with a still greater heat, the image of the copper coin was, as well as the others, most faithfully given, but the gold and silver only made permanent impressions.

7. A *silvered* copper plate was now tried with a moderate warmth (3). Mercurial vapor brought out good images of the gold and copper; the silver marked, but not well defined.

8. Having repeated the above experiments many times with the same results, I was desirous of ascertaining if electricity had any similar effect; powerful discharges were passed through and over the plate and disks, and it was subjected to a long-continued current without any effect. The silver had been cleaned off from the plate (7), it was now warmed with the coins and medals upon it, and submitted to discharges from a very large Leyden jar; on exposing it to mercurial vapor, the impressions were very prettily brought out, and strange to say, spectral images of those which had been received on the plate when it was silvered (7); thus proving that the influence, whatever it may be, was exerted to some depth in the metal.

9. I placed upon a plate of copper, blue, red, and orange colored glasses, pieces of crown and flint glass, mica, and a square of tracing paper. These were allowed to remain in contact half an hour. The space occupied by the red glass was well marked, that covered by the orange was less distinct, but the blue glass left no impression; the shapes of the flint and crown glass were well made out, and a remarkably strong impression where the crown glass rested on the tracing paper, but the mica had not made any impression.

10. The last experiment repeated, after the exposure to mercurial vapor; heat was again applied to dissipate it; the impression still remained.

11. The experiment repeated, but the vapor of iodine used instead of that of mercury. The impressions of the glasses appeared in the same order as before, but also a very beautiful image of the mica was developed, and the paper well marked out, showing some relation to exist between the substances used and the vapors applied.

12. Placed the glasses used above (9, &c.) with a piece of well-smoked glass for half an hour, one twelfth of an inch below a polished plate of copper. The vapor of mercury brought out the image of the smoked glass only.

13. All the glasses were placed on the copper and slightly warmed; red and smoked glasses gave after vaporization, equally distinct images, the orange the next; the others left but faint marks of their forms; polishing with Tripoli and putty powder would not remove the images of the smoked and red glasses.

14. An etching, made upon a smoked etching ground on glass, the copper and glass being placed in contact. The image of the glass only could be brought out.

15. A design cut out in paper was pressed close to a copper plate by a piece of glass, and then exposed to a gentle heat; the impression was brought out by the vapor of mercury in beautiful distinct-

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ness. On endeavoring to rub off the vapor, it was found, that all those parts which the paper covered, amalgamated with mercury, which was removed from the rest of the plates; hence there resulted a perfectly permanent white picture on a polished copper plate.

16. The colored glasses before named (9, 12) were placed on a plate of copper with a thick piece of charcoal, a copper coin, the mica and the paper, and exposed to a fervent sunshine. Mercurial vapor brought up the images in the following order: smoked glass, crown glass, red glass, mica beautifully delineated, orange glass, paper, charcoal, the coin, blue glass; thus distinctly proving that the only rays which had any influence on the metal, were the calorific rays. This experiment was repeated on different metals, and with various materials, the plate being exposed to steam, mercury and iodine; I invariably found that those bodies which absorbed or permitted the permeation of the most heat gave the best images. The blue and violet rays could not be detected to leave any evidence of action, and as spectra imprinted cn photographic papers by light, which had permeated these glasses, gave evidence of the large quantity of the invisible rays which passed them freely, we may also consider those as entirely without the power of effecting any change on compact simple bodies.

17. In a paper which I published in the Philosophical Magazine for October, 1840, I mentioned some instances in which I had copied printed pages and engravings on iodized paper, by mere contact and exposure to the influence of the calorific rays, or to artificial heat. I then, speculating on the probability of our being enabled by some such process as the one I then named, to copy pictures and the like, proposed the name of Thermography, to distinguish it from Photography.

18. I now tried the effects of a print in close contact with a well-polished copper plate. When exposed to mercury, I found that the outline was very faithfully copied on the metal.

19. A paper ornament was pressed between two plates of glass, and warmed; the impression was brought out with tolerable distinctness on the under and warmest glass, but scarcely traceable on the other.

20. Rose leaves were faithfully copied on a piece of tin plate, exposed to the full influence of sunshine, but a much better impression was obtained by a prolonged exposure in the dark.

21. With a view of ascertaining the distance at which bodies might be copied, I placed upon a plate of polished copper a thick piece of plate glass, over this a square of metal, and several other things, each being larger than the body beneath. These were all covered by a deal box, which was more than half an inch distant from the plate. Things were left in this position for a night. On exposing to the vapor of mercury it was found that each article was copied, the bottom of the deal box more faithfully than any of the others, the grain of the wood being imaged on the plate.

22. Having found by a series of experiments that a blackened paper made a stronger image than a white one, I very anxiously tried to

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effect the copying of a printed page or a print. I was partially successful on several metals, but it was not until I used copper plates amalgamated on one surface, and the mercury brought to a very high polish, that I produced any thing of good promise. By carefully preparing the amalgamated surface of the copper, I was at length enabled to copy from paper, line engravings, wood cuts and lithographs, with surprising accuracy. The first specimens produced (which I have the satisfaction of now submitting to your inspection), exhibit a minuteness of detail and sharpness of outline quite equal to the early Daguerreotypes and the photographic copies prepared with chloride of silver.*

The following is the process at present adopted by me, which I consider far from perfect, but which affords us very delicate images.

A well polished plate of copper is rubbed over with the nitrate of mercury, and then well washed to remove any nitrate of copper which may be formed; when quite dry a little mercury taken up on soft leather or linen is well rubbed over it, and the surface worked to a perfect mirror.

The sheet to be copied is placed smoothly over the mercurial surface, and a sheet or two of soft, clean paper being placed upon it, it is pressed into equal contact with the metal by a piece of glass, or flat board; in this state it is allowed to remain for an hour or two. The time may be considerably shortened by applying a very gentle heat for a few minutes to the under surface of the plate. The heat must on no account be so great as to volatilize the mercury. The next process is to place the plate of metal in a closed box, prepared for generating the vapor of mercury. The vapor is to be slowly evolved, and in a few seconds the picture will begin to appear; the vapor of mercury attacks those parts which correspond to the white parts of the printed page or engraving, and gives a very faithful, but somewhat indistinct image. The plate is now removed from the mercurial box, and placed into one containing iodine, to the vapor of which it is exposed for a short time; it will soon be very evident that the iodine vapor attacks those parts which are free from mercurial vapor, blackening them. Hence there results a perfectly black picture contrasted with the gray ground formed by the mercurial vapor. The picture being formed by the vapors of mercury and iodine, is of course in the same state as a Daguerreotype picture, and is readily destroyed by rubbing. From the depth to which I find the impression made in the metal, I confidently hope to be enabled to give to these singular and beautiful productions a considerable degree of permanence, so that they may be used by engravers for working on.

It is a curious fact that the vapors of mercury and of iodine attack the plate differently, and I believe it will be found that vapors have some distinct relation to the chemical, or thermo-electrical state of the bodies upon which they are received. Moser has observed this, and

* The first faithful copy of the lines of a copper-plate engraving was obtained by Mr. Cantabrana, who has since succeeded in procuring some tolerable specimens on unamalgamated copper, which cannot be rubbed off.

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attributes the phenomena to the colors of the rays, which he supposes to become latent in the vapor on its passing from the solid into the more subtile form. I do not however think this explanation will agree with the results of experiments. I feel convinced that we have to deal with some thermic influence, and that it will eventually be found that some purely calorific excitement produces a molecular change, or that a thermo-electric action is induced, which effects some change in the polarities of the ultimate atoms of the solid.

These are matters which can only be decided by a series of well-conducted experiments, and, although the subject will not be laid aside by me, I hope the few curious and certainly important facts which I have brought before you, will elicit the attention of those whose leisure and well-known experimental talents qualify them in the highest degree for the interesting research into the action of those secret agents which exert so powerful an influence over the laws of the material creation. Although attention was called to the singular manner in which vapors disposed themselves on plates of glass and copper, two years since, by Dr. Draper, Professor of Chemistry at New York, and about the same time to the calorific powers of the solar spectrum, by Sir John Herschel, and to the influence of heat artificially applied, by myself (17), yet it is certainly due to M. Moser of Konigsberg, to acknowledge him to be the first who has forcibly called the attention of the scientific world to an inquiry which promises to be as important in its results as the discovery of the electric pile by Volta.

As to the practical utility of this discovery, when we reflect on the astonishing progress made in the art of photography since Mr. Fox Talbot published his first process, what may we not expect from thermography, the first rude specimens of which exhibit far greater perfection than the early efforts of the sister art?

As a subject of pure scientific interest, thermography promises to develope some of those secret influences which operate in the mysterious arrangements of the atomic constituents of matter, to show us the road into the yet hidden recesses of nature's works, and enable us to pierce the mists which at present develope some of the most striking phenomena, which the penetration and industry of a few "chosen minds" have brought before our obscured visions. It has placed us at the entrance of a great river flowing into a mighty sea, which mirrors in its glowing waters some of the most brilliant stars which beam through the atmosphere of truth. Philos. Mag.

Mr. Baggs' Carbonic Acid Gas Engine.

The theory of the new power engine, which we have now to bring under the notice of our readers, is principally based on the discoveries of modern chemistry; and it may be as well, in a few words, to advert to these discoveries, before entering into the details of Mr. Baggs' application of them.

It is generally known, that many of those gases, which were

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formerly deemed permanently aëriform, are not so in fact, an alteration in their physical constitution being really effected by specific variations of pressure and temperature. Carbonic acid gas assumes the liquid form under a pressure of 36 atmospheres, or 540 lbs. to the inch, at a temperature of 32°. Ammoniacal gas becomes liquid under a pressure of 6.5 atmospheres, at the temperature of 50°; and very slight increments of heat are sufficient to exalt the elasticity of these bodies to such an extent, as to render them competent agents for the movement of machinery.

Attempts have accordingly been made to substitute their powers for those of steam, but, as yet, with no succesful result; the failure being mainly attributable to a want of economy in their production. Now, if we could manage, by any means, to *recover* these gases after they had done duty in the cylinder of an ordinary engine—if we could only save them from running to waste, cause them to perform their office over and over again, and effect all this at a small expense, it will be obvious that the great difficulty which has stood in the way of previous experimentalists would be avoided, and we should have at command an exceedingly cheap and portable power. This, then, is what Mr. Baggs has done; or, at least, shown the means of doing.

Mr. Baggs proposes to *generate the gas through the medium of a fixed acid, and a carbonate of the volatile alkali.* For instance: by pouring *phosphoric acid* upon carbonate of ammonia, *phosphate of ammonia* is produced, and carbonic acid gas is driven off; and by subjecting this phosphate of ammonia to heat, it is decomposed, ammoniacal gas is liberated, and the phosphoric acid originally employed in the first part of the process remains behind. Here, then, is the regeneration of one of the materials by the aid only of a small quantity of fuel; and the recovery of the other is even more simple. The carbonic and ammoniacal gases, produced as above described, after performing the office of steam in an appropriate engine, are allowed, by virtue of their non-elasticity, to rush into an exhausted receiver, where they no sooner come into contact than immediate condensation ensues, with the reproduction of the exact quantity of carbonate of ammonia destroyed in the commencement of the process.

It will be observed that there are but *three* proximate elements concerned throughout—phosphoric acid, carbonic acid, and ammonia, which, by the consecutive influences of chemical affinity and caloric, are made to undergo a definite series of actions amongst themselves, with the resulting evolution of an enormous mechanical power.

With regard to the acid employed, Mr. Baggs does not consider it to be essential that the phosphoric should be used; any *fixed* acid will answer the purpose, and the boracic and sulphuric acids are offered as examples. The question of preference is one of economy alone. Phosphoric acid is one of the principal constituents of bones, and the process for its extraction is sufficiently simple. Boracic acid is found native, and may also be obtained in abundance from borax. Sulphuric acid, it is well known, is plentiful enough; and with reference to the other ingredient, carbonate of ammonia, the sources of its supply are perpetual, cheap, and abundant.

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Supposing the invention to be applied to a locomotive, Mr. Baggs proposes to adopt the following routine. At any given station or line of stations, proper arrangements are to be made for carrying on the manufacture of gases in the way we have described. As the latter are produced they are to be condensed into a liquid form, either by the chemical process of Dr. Faraday, or by the mechanical method of compression, which originated with Sir M. Isambard Brunel. The two liquids thus obtained would form the only load which the engine would be required to carry; and the carbonate of ammonia would be re-formed *on the road* as the liquids were expended. All the other parts of the process are to be conducted at the station.

The condensation of the gases will be attended by the evolution of a great quantity of caloric, and, in order to reduce the amount of this in the condenser, as well as to increase the elasticity of the gases before they enter the working cylinders, the induction pipes are made to embrace the condenser.

By the transfer of caloric (thus effected) from the interior to the exterior of the condenser, the pressure within will be lessened, and that without increased, the power being thereby nearly doubled. When the stock of liquid material is consumed, it is to be replenished at the station; and the carbonate of ammonia is to be withdrawn from the condenser, by the removal of one of the hemispherical ends.

Another mode of employing the condenser, which Mr. Baggs points out, is by effecting a solution of the salt which it contains, and allowing the liquid to flow out. Lond. Mech. Mag.

Wrought Iron Axles.

Sir—It is worthy of remark how slowly well proved facts, individually acknowledged and acted upon, become generally admitted; it is to be regretted that we are not more communicative of those events which strike us in our daily practice, and which, if announced as soon as discovered, would so materially and rapidly tend to general improvement. There is, perhaps, no instance in which this can be more clearly exemplified than in the use of wrought iron; it is scarcely possible to refer to the subject without an example being readily laid before you. Every manufacturer has had, more or less, his attention drawn to the fact, that in its various applications wrought iron is subject to become brittle. Iron spindles, piston rods, fire bars, crow bars, chisels, and many other things, are known to lose their fibrous quality after being in use for a length of time, varying according to the nature of the service they have had to perform. By some it has been considered that the iron originally employed was of bad quality, and the circumstance when discovered has not been otherwise attended to than by replacing the broken piece; but in many instances the phenomenon has been clearly established, closely examined, and well attended to, and that for years together, without, however, having become a generally acknowledged fact, sufficiently positive to justify the opinion that wrought iron, applied for certain purposes, ought only to be allowed to perform a previously deter-

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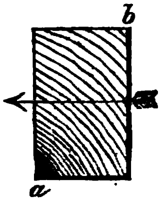
mined quantity of work, after which it becomes requisite to re-forge the piece.

In most cases the fracture may be unattended with danger to human life, but in others, as in connexion with railways, where hundreds of lives may depend on the strength of an axle, it daily becomes more evident that extraordinary precautions must be resorted to for the purpose of avoiding accidents, and I would, with regard to railway axles, suggest (as a precautionary measure) the propriety of limiting the distance they should be allowed to run previous to their being thrown out as unfit for service, and that whether apparently in good condition or not. Such is the perfection with which these axles can now be manufactured, that when a suitable quantity of iron is used, it may be confidently asserted that every axle turned out of the shop after due examination may be considered to be sound, and that by limiting the work it is allowed to perform, the fracture of an axle would become a very improbable event.

Having been lately in Paris, I mentioned the circumstance to M. Arnoux, the directing manager of the extensive works belonging to the Messageries, Laffitte & Caillard, persuaded that from a person whose attention has been for so many years engaged on this subject, I should obtain some positive information; he showed me a number of axles which he had caused to be broken, after they had performed their allotted quantity of work; they all broke short and brittle, the fracture invariably indicating the progress of the disease. The fracture commences at the lower angle of the axle on the side of the traction, which is evidently, in fixed axles, the point of greatest fatigue, and in those axles which have given way under the weight of the load, the fissure has in some instances nearly traversed the axle before it broke entirely, and it is then very easy to trace the accident from its origin. I will endeavor to describe its usual appearance by the following diagram; the arrow shows the direction in which the carriage moves.

b



a

The fracture invariably originates at the angle *a*, and appears to progress at intervals by zones, as shown by the lines in the diagrams; the first, at the point *a*, becoming perfectly black, the color of each being lighter as they gradually extend from this point, and as the contact of the two sides of the fracture becomes more intimate, the grain of the iron towards the angle *a* is coarse, and has a large, crystaline texture, which diminishes in size as the fracture approaches the angle *b*, at which point the metal remains slightly fibrous, having evidently undergone a more rapid deterioration at its point of greatest strain.

M. Arnoux informed me, that in consequence of this effect, to which he has for a long time paid great attention, he has come to the conclusion that an axle can only safely run a distance of 30,000 leagues, or about 75,000 English miles; when an axle has run that distance, he invariably takes it out, places it between two new bars of iron, and welds them together so as to form a new axle. If the carriage usually runs over a paved road, such as is frequently met

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with in France, the axle is not allowed to run so great a distance, and a certain degree of wear in the collar then determines the period at which the axle is thrown out; not in consequence of the wear of the collar, but because that degree of wear has proved, by experience, that it is prudent to renew the axles in order to avoid a fracture.

Here, then, we have the proof of an important principle in the application of wrought iron, being well established and long known to one, and probably to many, individually, without having come to the knowledge of railway engineers, who are thus compelled to arrive at this important truth by dint of actual experience, obtained through the medium of a series of lamentable accidents; and they could not acquire their information in any other way, unless made acquainted with the circumstance by those who have previously purchased their knowledge.

The question, then, admitting the above statement to be correct, will be, how great a distance it may be prudent to allow railway axles of different descriptions to run; and to solve this question, it will be advisable, in the first instance, to adopt a term which may certainly be within the limit of perfect safety, until the greatest distance that can be safely adopted may have been determined by a series of well conducted experiments.

Iron exposed to great heat undergoes the same kind of deterioration. I examined, in the same establishment, several bars taken from a furnace in which they heat their wheel hoops; the part of the bar directly exposed to the fire offered the same crystaline appearance as the broken axles, which gradually diminished towards the end that was out of the fire, and the end of the bar which was out of the fire altogether, had the appearance of good tough iron. The portion which had suffered most from its direct contact with the heat, having been doubled over and welded, entirely recovered its fibrous quality, and stood a cold bend as well as any iron that had been in the fire.

Should you find this communication worthy a place in the *Journal*, you will oblige, by its insertion,

Your obedient servant,

20th Jan., 1843. H. H. Edwards.

Civ. Eng. and Arch. Jour.

Use of Sulphate of Ammonia in Agriculture.

For the full development of the capacity of the soil, and to afford a greater amount of nitrogen than what is afforded either by the ordinary manure, or the ammonia, &c. of the atmosphere, sulphate of ammonia has been introduced, and found to be a most valuable auxiliary, as a top dressing, to the farmer.

It has been found to impart a greater degree of fructification to grass, wheat, and other grain, than any other dressing yet discovered, and at a less cost by 50 per cent.

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The mode of application as adopted by Mr. C. Hall of Havering-atte-Bower, Essex, is as follows:—

Having selected several fields of grass, peas, turnips, and wheat, he had sown broadcast on parts of these fields quantities at the cost of 5*s.* 3*d.*, 11*s.* 4*d.* and 21*s.* per acre; the sulphate having cost him 17*s.* per cwt.

The produce was kept and threshed separately, when the increase from the wheat land was found to be as follows:—

The part that was sown at the rate of 5*s.* 3*d.* per acre gave an increase of 3 bushels; 11*s.* 4*d.* gave six bushels, and 21*s.* upwards of 9 bushels, besides a considerable increase of straw.

Philos. Mag.

Mechanics' Register.

Report from the Commissioner of Patents, showing the operations of the Patent Office during the year 1842.

Patent Office, *January*, 1843.

Sir: In compliance with the law of Congress, the Commissioner of Patents has the honor to submit his annual report.

Five hundred and seventeen patents have been issued during the year 1842, including *thirteen* re-issues, and *fifteen* additional improvements to former patents, of which classified and alphabetical lists are annexed, (marked B and C.)

During the same period, three hundred and fifty-two patents have expired, as per list marked D.

The applications for patents during the year past amount to *seven hundred and sixty-one*, and the number of caveats filed was *two hundred and ninety-one.*

The receipts of the office for 1842 amount to $35,790.96, from which $8,086.95 may be repaid on applications withdrawn, as per statement E.

The ordinary expenses of the Patent Office for the past year, including payments for the library and for agricultural statistics, have been $23,154.48, leaving a net balance of $5,264.20, to be credited to the patent fund, as per statement marked F.

The above expenditures do not include those incurred within the last year, for the recovery of the stolen jewels.

For the restoration of models, records, and drawings, under the act of March 3, 1837, $14,060.02 have been expended, as per statement marked G.

The whole number of patents issued by the United States, previous to January, 1843, was *twelve thousand nine hundred and ninety-two.* The continuance of the depression of the money market, and the almost universal prostration of all business, operate very disadvantageously on the receipts of this office, as many hundred applications are delayed solely from the want of funds or difficulty of remittance. The patents granted for the year, however, exceeded

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those of the year previous by *twenty*, though there have been less applications by *eighty-six*.

The Digest of Patents, continued and brought down to January, 1842, has been printed, and 700 copies distributed to the respective States, and 200 copies deposited in the library, in compliance with the resolution of Congress directing the same.

The accommodations granted during the last year for the reception of the articles received through the exploring expedition, intrusted to the National Institute, must seriously thwart, if not suspend, the design of Congress in the reorganization of the Patent Office, which enacts, section 20, act of July 4, 1836, "that it shall be the duty of the Commissioner to cause to be classified and arranged, in such rooms and galleries as may be provided for that purpose, in suitable cases, when necessary for their preservation, and in such manner as shall be conducive to a beneficial and favorable display thereof, the models, and specimens of composition and fabrics, and other manufactures, and works of art, patented or unpatented, which have been or shall hereafter be deposited in the said office."

While the annual receipts of the Patent Office above the expenditures are sufficient to carry out fully the benevolent object of the National Legislature, the want of room of which it is thus deprived will be, for a time, an insurmountable obstacle, as all the room in the gallery could be advantageously used either by the Patent Office or the National Institute. No remedy, therefore, remains, but an extension of the building, which might be done by the erection of a wing sufficiently large to accommodate the Patent Office, on the first story. The building can also afford room for lectures by professors, should they be appointed under the Smithsonian bequest; and may I be permitted here to observe, that a gratuitous course of lectures in the different branches of science would certainly do much to diffuse knowledge among men. I can confidently say, that the agricultural class look forward with bright anticipations to some benefit from the Smithsonian bequest, and to the time when the sons of agriculturists, after years of toil at the plough, can attend a course of lectures at the seat of Government, and there learn, not only the forms of legistion, but acquire such a knowledge of Chemistry and the arts as will enable them to analyze the different soils, and apply agricultural chemistry to the greatest effect. Such encouragement will, indeed, stimulate them to excel in their profession, while others, deemed by many more favorable, are indulged with a collegiate course of education. Little, indeed, has been done for husbandry by the General Government; and, since eighty per cent. of the population are more or less engaged in the pursuit, the claim on this most beneficial bequest will not, it is hoped, be disregarded. The National Agricultural Society, in connexion with the Institute, will most cheerfully aid Congress in carrying out their designs, for the great benefit of national industry.

It is a matter of sincere congratulation, that the Patent Office has so far recovered from its great loss in 1836, by the conflagration of the building, with all its contents. A continued correspondence with

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11,000 patentees, and untiring efforts on the part of all concerned with this bureau, have accomplished much; indeed, to appearance, the models are better than previous to the fire. Although something yet remains to be done, enough has been accomplished to remove the past embarrassment, and afford applicants the means of examination as to the expediency of applying for a patent.

The loss to the library, sustained by the fire, is not yet fully repaired; and, since the law of 1836 makes it a duty to examine all applications for patents, with reference, also, to foreign inventions, it is absolutely necessary that the library should be extended.

It is true that the library of Congress possesses some books on scientific subjects, useful for reference in the labors of this bureau, but no permission is given to take out books from that library; and, if such liberty were granted, it would be bad economy to send an examiner to the Capitol, to look up similar cases. If applications are to be examined, it will promote the despatch of public business, protect against spurious patents, and give public satisfaction, if the Patent Office library is well supplied with necessary books.

Already, hundreds of applicants are satisfied, by the comparatively imperfect examinations now made by referring to books on hand, not to take out a patent; and when, in the rejection of cases, reference is made to foreign patents, there is an impatient desire to see the description of the invention that is to cut off the hopes of so many years of toil and labor. I would therefore most earnestly recommend an appropriation of $1,200 from the surplus fund, to add to the Patent Office library.

The annual agricultural statistics, comprising the tabular estimate of the crops for the past year, with accompanying remarks and appendix, will be found subjoined, (marked A.)

The value of this document to the whole country, from year to year, it is believed, would justify a much larger appropriation from the Patent Office fund for this purpose. The diffusion of such information may save millions to the laborious tiller of the soil, besides adding directly to his means of export many millions more. An examination of this subject, and the expediency of fixing it on a more permanent and advantageous basis, by the constitution of an agricultural bureau, or at least an agricultural clerkship, at a moderate expense, to be drawn from the patent fund, is respectfully suggested. The additional benefit which might thus accrue to the population of our widely extended country would soon be seen.

A sufficient appropriation to allow a personal examination of the various parts of the country, by some one well qualified for such duty—similar to what has been attempted with so much success by some of the State Legislatures—would, it is believed, realize a vast amount of practical good, especially to the South and West, by furnishing the data on which they might direct their products to the best markets, for domestic sale or foreign export.

Such, indeed, are the great benefits to result from personal observation and critical examination, not only of the crops, but agricultural

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implements—such the importance of explaining the new improvements, and collecting and distributing all the acclimated seeds, which are proved to be so signally productive or beneficial, that the Commissioner of Patents has doubted whether a modification of his duties, in connexion with the Patent Office, would not be more useful to the community. During the last year, he embraced the opportunity, while traveling, to examine the crops in ten States; and though the examination was of course imperfect, it enabled him the better to digest the somewhat discordant materials from which the agricultural statistics here incorporated were compiled. If millions can be saved to the public, if the agriculturalist can be encouraged in his all-important pursuits, by the expenditure of a small sum from the annual surplus of the patent fund, what better destination could be given to this amount? Would not the people heartily approve and earnestly second such an undertaking?

All which is respectfully submitted,

H. L. Ellsworth.

List of American Patents which expired in 1842.

Apples, machine for grating—U. Emmons, city of New York, Feb. 13.
Atmospheric Engine—E. A. Talbott, Dublin, Ireland, June 21.
Axle—D. Phillips, of Middlebury, and W. Mahar, Covington, New York, April 23.
Bands, metallic, communicating power—J. Eve, Augusta, Georgia, May 1.
Bark Mill—A. Bull, Caroline, New York, March 27.
———— J. Montgomery, Saugerfield, New York, May 29.
Barrels, Kegs, &c., machinery for making—Goodrich & Tainter, Waterbury, N. Y. June 9.
Bedsteads—S. Hyde, Arcadia, New York, May 2.
———— Swift & Ottiwell, N. Bedford, Mass., Oct. 11.
———— H. Wilbur, Newburyport, Mass., June 16.
———— revolving rail and round tenons—G. Post, Auburn, New York, Oct. 11.
Bees, management of—F. Kelsey, Lockport, New York, Aug. 26.
Bellows—E. Brady, Mount Pleasant, New York, April 3.
Binnacle lamps—W. Lewis, Boston, Mass., June 24.
Blocks, snatch—J. Evans, Charlestown, Mass., Dec. 6.
——— used in stereotype printing—S. Goodrich, Boston, Mass., Oct. 11.
Boats for canals—B. Phillips, Philadelphia, Pa., April 21.
Bobbin machine—J. A. Post, Warwick township, New York, April 23.
——— and flyers for cotton speeders—C. Danforth, Ramapo, New York, Sept. 2.
Boilers for steam engines—J. P. Allaire, city of New York, May 14.
———— A. Potter, city of New York, Oct. 11.
——— for oil and refining sugar—W. A. Archibald, Baltimore, Md., May 29.
Boot for stages—P. Laporte, Augusta county, Va., July 28.
—— tree—J. Ayars, Brookfield, New York, Nov. 27.
———— H. B. Miller, Maysville, New York, Aug. 25.
Boxes for sugar, making, by machinery—Pearson & Home, Alria, Maine, April 15.
Brake, wagon, self-regulating—T. Turner, Ward, Mass., Aug. 29.
Brick machine—D. Rising, Colchester, N. Y., Jan. 29
———— D. Flagg, Gardiner, Maine, March 19.
———— on M'Donald's—M'Donald & M'Queen, city of New York, Nov. 19.
Brick press—E. & D. W. Duty, Painesville, Ohio, June 7.
—— and tile press—E. Mayo, Hallowell, Maine, Dec. 9.
———— S. Parker, Gardiner, Maine, Nov. 29.
Buildings, covering—H. Knowles, Colchester, Conn., Oct. 10.
Cables, proving chain and hemp—J. Judge, Washington, D. C., Nov. 29.
Cannon lock, percussion—J. Shaw, Philadelphia, Pa., Oct. 24.

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Carriage bodies—J. Reeder, Lebanon, Ohio, Nov. 4.
———, railway—R. Winans, Vernon, N. J., Oct. 11.
———, improvement in—T. Knox, Sniggersville, Va., March 15.
Casks, barrels, &c., making—W. & M. Adams, Ogden, N. Y., June 4.
——— ——— machine for making—J. Hale, Oakum, N. Y., June 21.
Cements, fire and water proof—J. Coburn, Middlesex county, Mass., Sept. 3.
Cheese press—Hitchcock & Stone, city of New York, July 24.
——— L. Martin, Grantsville, N. Y., Dec. 19.
Churn—S. H. Baker, Wells township, Pa., Jan. 10.
——— J. Hathaway, Canandaigua, N. Y., Aug. 22.
——— E. Spain, Mount Holly, N. J., April 23.
——— and washing machine—D. Read, Slatersville, N. Y., June 16.
——— J. Grout, Caroline, N. Y., Oct. 10.
——— R. R. Palmer, Caroline, N. Y., March 21.
Cloth machine, vibrating and napping—S. Duncan, Northampton, N. Y., Jan. 21.
—— manufacture—J. P. & R. G. Hazard, Providence, R. I., Dec. 6.
—— manufacturing—J. P. & R. G. Howell, Providence, R. I., Dec. 6.
—— shearing—J. & G. C. Kellog, New Hartford, Conn., April 7.
Collars for dress coats—H. Clark, Brooklyn, N. Y., Nov. 7.
Combs, machine for grailing—P. Pratt, Meriden, Conn., Feb. 12.
Compass, mariners', fixing—L. Langley, Gosport, Va., June 23.
Composition for roofs, fire and water proof—D. Greer, Pittsburgh, Pa., April 25.
Cooking apparatus—E. Bennett, Kingsbury, N. Y., Feb. 15.
——— stove—A. Fisher, Claremont, N. H., May 9.
——— D. G. Garnsey, Pomfret, N. Y., March 8.
——— R. C. Rouse, Athens, N. Y., Jan. 26.
Coopers' work, manufacturing—H. Waters, Watertown, N. Y., April 3.
Corn sheller—T. I. Deane, Virgin, N. Y., Dec. 8.
——— P. Grosjeane, Louisville, Ky., July 29.
——— W. Hoyt, Vernon, Ind., April 29.
Cotton gin feeder—J. Ewbank, Jr., Glasgow, Ky., July 29.
——— picker—Pennell & Maxon, Barboursville, Va., Oct. 10.
——— press—W. J. Cocke, Cabin Point, Va., Feb. 4.
———, spinning and twisting; J. Thorpe, Providence, R. I., Nov. 20.
Cough drops; D. E. Smith, Cornwall, Conn., June 30.
Cultivator; R. Herbert, Williamson co., Tenn., April 19.
Curriers' knife; J. H. Harrington, Albany, N. Y., June 26.
——— do. do. do. " 28.
Cutting cabbages; Berkeymeger & Dangler, Greenwich, Pa., Nov. 10.
——— rags; M. Y. Beach, Springfield, Mass., Oct. 18.
Distilling; Laws & Monteith, Louisville, Ky., July 30.
——— J. R. Nance, Floyd, Ind., Dec. 27.
——— by steam; B. Barr, Strasburgh township, Pa., April 5.
——— spirits; J. Hungus, Hempfield township, Pa., May 17.
——— ——— from still slops; D. White, Fredonia, N. Y., June 17.
——— spirituous liquors; W. J. Cocke, Cabin Point, Va., Feb. 4.
Dock; N. Saltonstall, New London, Conn., May 29.
Doors, constructing; D. Williams, Jr., Colchester, Conn., Oct. 14.
Drawing and corking sparkling liquors; S. A. Billie, city of New York, Nov. 8.
Dressing staves; L. Benton, Hanover, N. Y., July 12.
Dysentery, dyspepsia, &c.; T. Powell, Burlington, Vt., Feb. 2.
Dyewood and tan bark cutting, self-feeding—A. Foster, Rochester, N. Y., Dec. 9.
Excavator, floating; H. W. Campbell, Lockport, N. Y., Jan. 22.
Fastenings for window shutters; T. Bartholemew, city of New York, Feb. 19.
Felloes; G. Andrews, Tolland, Conn., Oct. 24.
——— sawing and cutting; S. Fahrney, Washington co., Md., Dec. 9.
Fencing, repairing; E. Pitkin, East Hartford, Conn., Dec. 13.
Files, machine for cutting; J. Hatch, Roxbury, Mass., Oct. 10.
Filtering water; C. Hall, Norfolk, Va., Feb. 22.
——— J. S. Phillips, Philadelphia, Pa., Aug. 27.
Fire engine; E. Daboll, Canaan, Conn., April 12.
Flax, swingling; S. Ackey, Heidelberg township, Va., Feb. 18.
—— and hemp machine; E. Christian, Philadelphia, Pa., Feb. 8.

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Flax and hemp machine; J. C. Wentzell, Louisville, Ky., Jan. 17.
Flutter wheel, application of water to; J. Stewart, Robertson county, Tenn., Oct. 24.
Forcing pump, quadruple; J. Ferris, Ellicott, N. Y., Aug. 12.
Furnace, iron; B. B. Howell, Philadelphia, Pa., Oct. 14.
——, steam, for anthracite coal; B. B. Howell, Philadelphia, Pa., Oct. 14.
Gas, inflammable during the combustion of anthracite coal; Ward & Hall, Baltimore, Md., Jan. 19.
Gates for locks of canals; D. Rogers, Little Falls, N. Y., Jan. 14.
Generator, tubular, steam; B. R. Throckmorton, city of New York, Jan. 17.
Glass knobs; T. B. & J. P. Bakewell, Pittsburgh, Pa., March 14.
——, melting and fusing; T. W. Dyott, Philadelphia, Pa., Oct. 10.
——, moulding, &c.; D. Jarvis, Boston, Mass., Dec. 1.
Gold and silver, separating from the earth; W. H. Folger, Spartanburgh, S. C., Feb. 13.
Gout nostrum; E. Smith, city of New York, Dec. 15.
Grist mill; J. Crarl, Warren, Ohio, June 19.
—— S. Holland, Hanover, Ohio, March 1.
—— R. Medley, Bloomfield, Ky., Sep. 5.
—— Smith & Sapp, Mount Vernon, Ohio, Sep. 8.
—— W. L. Taylor, McMinn, Tenn., Jan. 28.
—— A. Warren, Saugerties, N. Y., March 12.
Gum, extracting from unrolled flax; S. Olcott, Harsimus, N. J., Dec. 3.
Hammer, cast iron; T. Jones, Glastonbury, Conn., July 31.
—— for cutting and dressing granite; J. Richards, Braintree, Mass., Feb. 20.
Hat bodies; West & Stevens, Richland, N. Y., Oct. 29.
——, machinery for manufacturing; G. L. Thatcher, Brooklyn, N. Y., May 31.
Hatters' carding machine; J. Sandford, Blockley, Pa., Oct. 10.
Hay presses; M. B. Bliss, Pittstown, Maine, Jan. 26.
Heat, evolving and management of; E. Nott, Schenectady, N. Y., March 26.
——, production of; S. A. Bille, city of New York, Nov. 8.
Hemp brake; J. S. Vandergriff, Scott co., Ky., May 12.
——, preparation of; A. K. Smedes, Lexington, Ky., Oct. 11.
Hides, tanning and manufacturing; Shove & Hunt, Locke, N. Y., May 13.
Hoops, laths and staves, sawing; I. Price, Jr., Lockport, N. Y., Aug. 19.
——, machine for sawing; P. Slayton, Lockport, N. Y., May 1.
Horse, improving the shape of; A. Carman, Hyde Parke, N. Y., Nov. 27.
—— mill, lever; J. Galbraith, Maury co., Tenn., March 6.
—— shoes; R. E. Hobert, Pottstown, Pa., May 24.
Hose, &c.; J. A. Black, Columbia, S. C., Oct. 13.
Hubs and axletree; P. Slayton, Lockport, N. Y., Oct. 27.
——, cast iron; W. Dickerman, Batavia, N. Y., Oct. 6.
——, herculean carriage; H. Thomas, Medway, Mass., Feb. 8.
Hydrant fountain; L. Gauley, Philadelphia, Pa., Aug. 1.
Hydraulic elevator; J. M'Creery, Nobletown, Pa., Jan. 5.
—— engine, revolving; A. Hubbard, Windsor, Vt., April 22.
—— machine; W. Barker, Wilkesbarre, Pa., Aug 26.
Incline plane for raising and lowering canal boats; W. Knight, Morristown, N. J., Aug. 5.
—— transporting; M. Robinson, Henrico co., Va., April 9.
Ivory, machine for junking; Pratt & Bush, Meriden, Conn., Feb. 9.
Jackscrew for raising wagons; H. Salisbury, Springfield, Mass., March 8.
Lamp, signal; Feinour & Son, Philadelphia, Pa., Aug. 1.
——, safety compass; do. do. do. April 5.
Lathe, turning; J. Moore, Leverett, Mass., Jan. 19.
——, wheelwrights' felloe; Sitton & Black, Pendleton and Columbia, S. C., May 5.
Laths, &c., splitting; B. K. Crandell, Lockport, N. Y., Aug. 25.
—— and other timber, manufacturing—L. Rice, Lockport, N. Y., July 23.
Leather, belt and picker, preparing—I. J. Travis, Franklin, Conn., Oct. 22.
—— and cloth, water proof; T. L. Comstock, Hartford, Conn., Jan. 21.
——, machine for cutting; G. P. Mitchell, Burlington, N. J., May 15.
—— rolling machine; S. A. Brownson, Montrose, Pa., Dec. 26.
—— H. Paign, Alexandria, Miss., Dec. 23.
——, water proof; A. Straub, Milton, Pa., June 30.
Lever press; Wm. Linn, Danville, Va., April 25.
Lock, percussion; L. Caswell, Manlius, N. Y., May 8.

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Locks, percussion; J. Lawrence, New Berlin, N. Y., May 24.
———— water proof, self-priming; S. L. Faries, Middletown, Ohio, May 29.
—— wagon; J. M. Davidson, Brownsville, Pa., April 14.
—— —— George Divan, Franklin co., Pa., April 14.
Locomotive engine; W. Howard, Baltimore, Md., Dec. 10.
Longimeter; A. Bayard, South Reading, Mass., July 16.
Loom, power, check and plaid; Burt & Boyds, Manchester, Conn., Aug. 19.
—— sattinet, power; L. Marble, Henrietta, N. Y., June 22.
———— Mitchell & Butterworth, Troy, Mass., June 22.
Lotteries; J. J. Cohen, Baltimore, Md., Aug. 26.
—— drawing; W. E. Spalding, Brooklyn, Conn., Feb. 15.
Marble, sawing, cutting, and polishing; A. M'Alister, Salem, N. Y., Feb. 18.
Mats, from Manilla and other grass; S. S Williams, Roxbury, Mass., Aug. 22.
Medicine; F. Bird, Hancock, Ga., April 16.
—— J. Dent, Augusta, Ga., July 2.
Morocco, polishing, graining, and dicing; A. Bayard, South Reading, Mass., Dec. 29.
Mortising and tenoning machine; Jackson & Speed, Jr., Speedville, N. Y., Oct. 10.
—— machine; J. J. Kellog, Richmond, N. Y., Jan. 24.
———— W. E. March, Westfield township, N. J., April 18.
Mule drums, grooving; J. Butterworth, Philadelphia, Pa., Dec. 30.
—— for spinning cotton; T. Walker, Chester co., Pa., June 26.
Nails, wrought; H. Burden, Troy, N. Y., May 26.
Oil, pressing, from flaxseed; How, Brewster & Johnson, Newton, Colchester, and Chittenden, Vt., May 24.
Oven for baking over a cooking furnace; E. Moody, Northfield, Mass., April 5.
—— portable; F. L. Hedenburgh, city of New York, April 26.
Oyster platform; J. Freeland, city of New York, Oct. 29.
Paddle gate; J. F. King, Watertown, N. Y., Nov. 29.
Paint for plastered walls; A. Thompson, Bethany, N. Y., Feb. 2.
Paper, manufacturing; A. & M. A. Sprague, Fredonia, N. Y., Oct. 31.
———— W. Magaw, Meadville, Pa., March 8.
———— machine; Waterman & Annis, Providence, R. I., Aug. 30.
—— making, by the flat press; M. Haddock, city of New York, July 17.
——, preparing straw, hay, &c., for making; W. Magaw, Meadville, Pa., May 22.
——, top press roller for making; M. Hunting, Watertown, Mass., Oct. 20.
Pen microscopic machine; J. Bennett, Lowell, Mass., Oct. 11.
Peg cutting machine; H. Thurber, Painted Post, N. Y., May 22.
Piano fortes; C. F. L. Albright, Philadelphia, Pa., March 28.
———— fitting hammer heads to; J. Mackay, Boston, Mass., Aug. 14.
Pill, rheumatic; E. Dean, Biddeport, Mass., Feb. 2.
Pipes, leaden, testing; T. Packard, Sherburn, Mass., April 28.
—— of clay; T. Wickersham, Newbury, Pa., May 13.
Planting grain, machine for; O. Starr, Richmond, N. Y., Aug. 22.
—— machine; A. H. & L. Robins, Denmark, N. Y., Aug. 28.
Plough; J. Deats, Middletown, Pa., April 26.
—— R. Loveridge, Knox co., Ohio, March 8.
—— S. M'Cormic, Fauquier co., Va., Oct. 22.
—— W. Wiard, city of New York, Jan. 26.
——, bar share; J. Deakyns, Petersburg, Va., Nov. 18.
——, hill side; N. Staples, Penn's Grove, Va., Nov. 1.
Plugs, cutting, for decks and waists of ships; J. Josselin, city of New York, May 3.
Press frame, improvement on Brown's; R. Hoe, city of New York, April 22.
Pressing horn for combs; U. Bailey, West Newbury, Maine, Feb. 2.
Printing press; Holbrook & Thomas, Brattleboro', Vt., Feb. 7.
————, copperplate; C. Durand, city of New York, May 22.
————, cylindrical; C. G. Williams, city of New York, May 29.
———— roller; G. W. Cartwright, Mount Pleasant, N. Y., April 29.
———— J. Laird, Pittsburgh, Pa., Aug. 16.
Propelling boats by hydraulic apparatus; B. Phillips, Philadelphia, Pa., Aug. 16.
———— spring and main value; W. Willis, Charleston, S. C., May 2.
—— ships, &c.; A. Hermange, Baltimore, Md., May 31.
———— do. do. do. Nov. 26.
———— do. do. do. " 26.

Propelling vessels; H. Case, Norwalk, Ohio, Aug. 13.
Pump, applying power to common; N. Underwood, Baltimore, Md., July 17.
—— boxes; Williams & Rice, Salem, Mass., Dec. 9.
—— for beer, soda, water, &c.; L. Pitkin, Rochester, N. Y., Oct. 11.
—— logs, boring; G. W. Draper, Camillus, N. Y., March 31.
——, tide basin; G. M. Seldon, Troy, N. Y., March 10.
Punching copper; W. Ballard, Boston, Mass., Dec. 6.
Railway car; W. Howard, Baltimore, Md., Nov. 22.
——, submarine; J. Thomas, city of New York, Nov. 6.
Raising, &c., canal boats, without locks; W. Wiard, city of New York, March 1.
—— water by steam; J. S. Fox, Otto, N. Y., April 5.
—— from wells; S. Smith, Mendon, N. Y., Aug. 20.
Reaping machine; S. Lame, Hallowell, Maine, Aug. 8.
Reel for handling hides; W. Brown, Frankford, Pa., April 17.
Rice, machine for cleaning; J. Ravenal, Charleston, S. C., May 17.
—— thrashing machine; W. Warren, city of New York, Feb. 22.
Rifle, double shooting; Mosher & White, Hamilton, N. Y., May 5.
Rocks, boring; J. Overall, Liberty, Tenn., March 14.
Rope reeding machine; Boring & Jones, Thornville, Ohio, May 5.
Rosin, pine, for fuel; R. L. Wood, Philadelphia, Penn., Oct. 10.
Rotary steam engine; S. Blake, Providence, R. I., Oct. 11.
Ruler, triangular measurer; A. Ward, Philadelphia, Pa., Oct. 11.
Ruling paper; C. Lanuza, city of New York, Aug. 13.
Saddle spring; T. Harvey, Middletown, Del., Jan. 24.
Saddles; A. Marshall, Pikeland township, Pa., April 30.
Sausage cutter; S. Fahrney, Washington co., Md., Dec. 9.
Saw, circular; L. B. Bumb, Wareham, Mass., Aug. 28.
——, for clap boards; J. Kidder, Gorham, Me., Oct. 11.
—— frame, armed; N. Sperry, Nashville, Tenn., June 18.
—— mill; J. Call, Woodstock, Conn., April 28.
—— curvilinear; D. Baker, Ipswich, Mass., Aug. 7.
Sawing hoops; N. Brutt, Lockport, N. Y., July 31.
Screen, zigzag; J. Woodhull, Rochester, N. Y., Dec. 31.
Screws, archimedean; P. Harris, Preble co., Ohio, March 25.
——, arranging machinery for making; S. Wright, London, Eng., Dec. 6.
——, machine for cutting wooden; S. Treadwell, Western, Conn., May 22.
Scythe snethe; S. Lamson, Sterling, Mass., Dec. 29.
Self-loading car; W. Beach, Philadelphia, Pa, Feb. 5.
Shingle machine; How & Chaffin, Holden, Mass., May 22.
—— D. Wilder, Rome, N. Y., Aug. 25.
Shingles, sawing; C. Read, Western, Mass., April 2.
Shovels, scythes, &c., of cast steel and iron; E. A. Bulkley, Colchester, Conn., Feb. 28.
Shuttle for tying knots; J. Thorp, Providence, R. I., Nov. 20.
Slates, machinery for making; T. Symington, Baltimore, Md., Nov. 17
Sleigh shoes, cast iron; I. Arnold, Oswegatchie, N. Y., March 12.
Smut machine; T. Carpenter, Elmira, N. Y., Dec. 4.
Spine, infected, apparatus for; J. K. Casey, city of New York, June 23.
Spinner, domestic; E. Penney, Adams, N. Y., June 27.
—— ring groove; J. Thorp, Providence, R. I., Dec. 31.
Spinning and roping cotton wool; J. W. Wheeler, Galaway, N. Y., Oct. 11.
—— of filling, or slack twisted, yarn; J. Thorp, Providence, R. I., Nov. 29.
—— wool, flax, and hemp; T. T. Abbott, Greenland, N. H., Feb. 26.
—— and cotton; A. Critchfield, Union township, Ohio, April 24.
—— E. H. Collier, do. do. " 24.
Steam, application of; J. Skinner, Mantua, Ohio, March 14.
—— boats for canals; J. F. Wright, Erie, Pa., Feb. 14.
—— boilers; A. Hermange, Baltimore, Md., Nov. 26.
—— S. M. Richards, Chagrin river, Ohio, Aug. 21.
—— for stone coal; J. G. Wilson, city of New York, Feb. 22.
—— engine; E. Broadmeadow, do. Jan. 27.
—— P. Cooper, do. April 28.
—— attaching tubes to; G. Freeborn, do. July 8.

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Steam engine and steam power; W. Willis, Charleston, S. C., Feb. 1.
——————, high pressure safety; I. Jennings, city of New York, Feb. 11.
——————, specific; A. S. Kirk, Smithfield township, Ohio, Feb. 13.
———, gas, or vapor, generating; E. A. Lester, Boston, Mass., March 10.
Still, boilers, kettles, &c., setting; Miller & Clemmons, Clemmonsville, N. C., June 24.
Stone, making artificial; M'Kay, M'Kenzie & Woodbull, Caledonia, N. Y., Jan. 16.
Stove, Franklin; W. Cowden, Watertown, N. Y., June 16.
Stoves, chimnies, furnaces, &c.; J. J. Geraud, Baltimore, Md., Feb. 10.
Straw, Leghorn, &c., whitening; H. Cooper, Washington township, Pa., Nov. 12.
——— cutter; W. Cummings, Livingston co., N. Y., Feb. 11.
Sugar, filtering apparatus; W. A. Archibald, Baltimore, Md., May 29.
——— refining, double boiler, &c.; do. do. " 29.
Tables, breakfast and dining; P. Baker, Worthington, Ohio, Aug. 6.
Teeth, terro-metallic; A. Plantou, Philadelphia, Pa., April 5.
Threshing machine; S. L. Allen, Skaneateles, N. Y., Nov. 1.
———————— J. H. Barnet, Aurelius, N. Y., April 10.
———————— M. Barney, Nantucket, Mass., Aug. 5.
———————— N. Case, New Granville, Ohio, May 23.
———————— C. Emmons, city of New York, April 17.
———————— S. Felton, Kilbuck, Ohio, July 22.
———————— M. First, Uniontown, Md., March 3.
———————— E. Hoit, Charleston. S. C., Feb. 18.
———————— W. Loomis, Springfield, N. Y., March 6.
———————— Post & Byan, New Baltimore, Va., Oct. 10.
———————— for rice; W. Warren, city of New York, Feb. 22.
Tobacco, curing; M. & T. Baker, Louisa co., Va., March 4.
Tongs, cast iron; E. H. Buill, Marleborough, Conn., March 6.
Transporting and conveyance machine; J. J. Reekers, Baltimore, Md., July 21.
Trip hammer; L. Rosencrans, Big Falls, N. Y., March 17.
Types, casting printers'; W. Johnson, city of New York, Aug. 21.
—————— machine for; G. F. Peterson, do. Oct. 13.
Veneer saw frame; B. Crehore, Milton, Mass., May 22.
Vice for slitting iron; P. Pratt, Meriden, Conn., Feb. 12.
Washing, filling, and corking bottles; S. A. Bille, city of New York, Nov. 8.
————— machine; A. Bull, Cawline, N. Y., March 28.
———————— J. R. Davis, Hartland, N. Y., Sep. 2.
———————— G. Hancock, Maysville, Ky., May 24.
———————— J. & R. Hathaway, Pultney, N. Y., Sept. 5.
———————— M. Parker, Lowville, N. Y., May 1.
———————— S. Willard, Jr., Cincinnati, Ohio, Aug. 2.
————————, Leavitt's; E. M. Gibbs, Chenango co., N. Y., May 1.
————————, rotary; C. Post, Springport, N. Y., July 15.
————— and churning machine; J. Grout, Caroline, N. Y., Oct. 10.
—————————————— R. R. Palmer, do. March 21.
—————————————— D. Read, Slatersville, N. Y., June 16.
————— and pressing machine; H. Averill, Richland, N. Y., Aug. 14.
Washstand; J. Williams, Baltimore, Md., March 15.
Water, mode of obtaining; T. Davis, Lawrence, Ind., April 14.
——— pressure for propelling machinery; G. M. Gibbs, Williamsburg Dis., S. C., March 10.
——— power, increasing by atmospheric pressure; S. L. Holmes, Westchester, N. Y. Dec. 8.
——— wheel; J. Bell, Sycamore Spring, Ohio, May 9.
—————— A. Greenleaf, Mexico, N. Y., June 5.
—————— J. Torry, Ravenna, Ohio, Feb. 28.
—————— O. Thompson, Jericho, Vt., Dec. 6.
——————, hinged; M. D. Brown, Mason co., Va., Dec. 19.
——————, screw; E. Beard, Charleston, Mass., Jan. 25.
——————, spiral; J. Kelly, Jackson co., Ohio, Feb. 21.
Ways for drawing up vessels; A. Miller, New London, Conn., July 7.
Wicks, cotton yarn; G. Dickenson, city of New York, Feb. 21.
Windmill; A. Murray, Athens, Pa., July 8.
————— horizontal; W. Ingals, Sanbarton Bridge, N. H., Aug. 19.
Windlass; S. Nicholson, Boston, Mass., Dec. 1.

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Window blinds; J. Parkerson, Boston, Mass., Oct. 11.
——— fastenings; H. Seeley, Unadilla, N. Y., July 14.
——— sashes, cast-iron; J. M'Nary, Stafford, Conn., Feb. 23.
—————, blinds, &c.; J. Richards, Elbridge, N. Y., Nov. 12.
Wire cutting machine; A. Stevens, Andover, Mass., Nov. 11.
——, harness for weaving; E. Brown, Cazenovia, N. Y., Oct. 20.
Wool and cotton, spinning from the roll; W. R. M'Ball, Vincennes, Ind., May 12.
—— carding machine; H. A. Shannon, Columbia co., N. Y., April 5.
Wringing dyes, &c., out of cloths, &c.; W. Nelson, Batavia, N. Y., Nov. 13.
Yards of vessels, suspending; S. A. Wells, Boston, Mass., Jan. 23.

Meteorological Observations for December, 1842.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barmtr. Sun Rise.	Barmtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
⊗	1	27°	32°	29.56	29.65	W.	Blustering		Cloudy.	Cloudy.
	2	28	34	30.06	30.15	W.	Moderate		Cloudy.	Clear.
	3	32	48	29.73	29.73	W.	do		Cloudy.	Clear.
	4	38	44	29.83	29.80	SW.	do		Cloudy.	Cloudy.
	5	39	46	29.75	29.75	E.	do	.25	Cloudy.	Rain.
	6	30	35	30.15	30.20	NE.	do		Cloudy.	Par. cloudy.
	7	31	35	30.15	30.06	E. W.	do		Sleet.	Cloudy.
	8	32	33	29.96	29.85	NE	do	1.35	Rain.	Rain.
☾	9	35	43	29.50	29.50	NW.	do		Cloudy.	Cloudy.
	10	32	35	30.10	30.15	W.	do		Cloudy.	Cloudy.
	11	31	35	30.15	30.05	E. W.	do		Cloudy.	Cloudy.
	12	30	40	30.13	30.15	NW. NE.	do		Cloudy.	Cloudy.
	13	26	33	30.00	29.75	NE.	do	.36	Snow.	Rain.
	14	29	32	29.62	29.80	W.	do		Cloudy.	Cloudy.
	15	27	33	30.20	30.25	W.	do		Clear.	Flying clouds.
	16	22	33	30.10	30.10	W.	do		Clear.	Clear.
☺	17	38	40	29.50	29.50	W. SW.	do		Clear.	Lightly cloudy.
	18	24	38	29.80	29.70	W.	do		Cloudy.	Clear.
	19	26	42	30.00	30.03	W.	do		Clear.	Clear.
	20	34	38	29.80	29.60	NE.	do	.60	Cloudy.	Rain.
	21	39	40	29.36	29.40	W.	do		Cloudy.	Cloudy.
	22	18	26	30.30	30.30	W.	do		Clear.	Clear.
	23	14	24	30.30	30.40	W. SW.	do		Clear.	Clear.
☽	24	24	32	30.40	30.40	W.	do		Cloudy.	Cloudy.
	25	26	33	30.40	30.41	W.	do		Clear.	Cloudy.
	26	26	40	30.40	30.37	W.	do		Clear.	Clear.
	27	32	36	30.35	30.25	W.	do		Cloudy.	Cloudy.
	28	28	36	29.80	29.80	N.	do		Clear.	Clear.
	29	25	34	29.50	29.85	E.	do		Cloudy.	Snow.
	30	24	34	29.40	29.44	W. SW.	do		Clear.	Cloudy.
⊗	31	24	28	29.63	29.85	W.	do		Par. cloudy.	Clear.
		28.74	35.87	29.93	29.94			2.56		

Thermometer.		Barometer.	
Maximum 48 on 3d. Minimum 14 on 23d.	Mean 32.305	Max. 30.41 on 24th & 25th. Min. 29.36 on 21st.	Mean 29.93

Errata in Vol. IV.

Page 150,	line 17,	for	"*another,*"	read "*or other.*"
" 372,	" 16,	"	"*italics,*"	" "*detail.*"
" 372,	" 38,	"	"100,"	" "110."
" 374,	" 17,	"	"*on,*"	" "*or.*"
" "	" 26,	"	"*catching,*"	" "*arresting.*"
" "	" 34,	"	"*could,*"	" "*would.*"
" 375,	" 20,	"	"*as local,*"	" "*at local.*"
" 377,	" 6,	"	"*reservoir,*"	" "*resources.*"

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JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

APRIL, 1843.

Civil Engineering.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

[CONTINUED FROM PAGE 79.]

CHAPTER II.—*Vertical Revetments, considered on the Hypothesis of Sliding.*

42. The fact, mentioned at the end of the last chapter, as established by the discussion of Col. Audoy, is such as to become important under certain circumstances. The principal case arising will be in retaining walls at the foot of high embankments, or deep cuts. We therefore consider that it will be useful to go over the calculations of this learned engineer, and to carry our investigations to such an extent as to admit the least possible error, or uncertainty, in the determination of the coefficient of stability relative to the sliding of revetments on the beds of any of the courses of masonry.

Exposition of Formulas, and Formation of Tables of Thicknesses, relative to this case.

43. Continuing the notation adopted in numbers 1, 15 and 26, we shall, in the case where the back of the wall is vertical, have

$$(y) \qquad f^2(x-m)^2 + 2\frac{p'}{p}fx = \delta'\frac{f}{f'}(\sqrt{1+f^2} - \sqrt{u^2+f^2})^2(1+a)^2$$

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to express the conditions of equilibrium of stability relative to sliding on the foundation AB (fig. 1) of the wall; in which equation we shall always have (26)

$$u=\frac{a-f(x-m)}{a+1}, \text{ or } a+1=\frac{1+f(x-m)}{1-u}$$

with the particular condition of $a>f(x-m)$, or of u being positive. In substituting for $(a+1)$ its value in x and u, the equation (y) can be put under the form:

$$(z)\qquad \frac{pf^2(x-m)^2+2p'fx}{p[1+f(x-m)]^2}=\delta'\frac{f}{f'}\frac{(1+u)^2}{(\sqrt{1+f^2}+\sqrt{u^2+f^2})^2}.$$

44. For small loads (fig. 2), where the condition $a<f(x-m)$ is, on the contrary, satisfied, we shall simply have, (9) in observing that $n=0$,

$$\text{tang. } \theta=\text{tang. } \alpha=\frac{1}{f}, \text{ tang. } \tfrac{1}{2}\alpha=\sqrt{1+f^2}-f, \text{ \&c.},$$

$$x=p\frac{\delta' f(\sqrt{1+f^2}-f)^2(a+1)^2+f'a(a+2fm)}{2ff'(p'+ap)}.$$

45. It will be recollected, on the other hand, that, if the width of the base CI (fig. 1) of the prism of earth which covers the summit of the wall, is given, it will then be necessary to make use of the next to the last of the equations in number 11, which will allow us to calculate directly the value of x, or of e, without recurring to the solution of equation (z).

46. Also, on the supposition of $m=x$, $u=\frac{a}{a+1}$, or in the particular case when the berm equals the width of the wall, the equation (z) immediately gives,

$$x=\frac{\delta' p}{2f'p'}\frac{(2a+1)^2}{[(a+1)\sqrt{1+f^2}+\sqrt{a^2+f^2(a+1)^2}]^2},$$

for all values of a from zero to infinity. The latter value gives the formula:

$$x=\frac{\delta' p}{2f'p'(1+f^2)},$$

for calculating the finite limit of the thicknesses of vertical revetments, relative to the particular case under consideration.

47. The equation (y) or (z) generally being of the fourth degree in a and x, it will be necessary to resolve it by methods of approximation analogous to those of the 31st, and following, numbers, for either deducing the root applicable to any special case, or making regular tables of thicknesses of demi-revetments, relative to different loads of earth and to various hypotheses in regard to the values of m, f, p, and p'.

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Moreover, the formation of these tables will be much facilitated, because the equation (z) is explicitly of the second degree only in x, and, therefore, allows us to calculate directly this quantity for each of the values given to u, and, consequently, to deduce from it the corresponding value of a.

Supposing, for abridgment,

$$\frac{(1+u)^2}{(\sqrt{1+f^2}+\sqrt{u^2+f^2})^2}=V^2, \quad \delta'\frac{f}{f'}V^2=q,$$

and putting equation (z) under the form,

$$(w) \quad (q-1)f^2(x-m)^2+2\left(q-\frac{p'}{p}\right)f(x-m)+q-2\frac{p'}{p}fm=0,$$

we at once deduce from it, by resolving it with reference to $f(x-m)$,

$$x=m-\frac{pq-p'}{f(pq-p)}\pm\frac{1}{f}\sqrt{\left(\frac{pq-p'}{pq-p}\right)^2-\frac{pq-2p'fm}{pq-p}},$$

giving double roots, both of which may, at the same time, be positive, and may thus, in general, lead to two systems of simultaneous values of x and a, running in contrary directions, but related to a common value,

$$x=m-\frac{pq-p'}{f(pq-p)},$$

which is the result when the radical vanishes, that is, when we have chosen such a value for u as to give the relation,

$$\left(\frac{pq-p'}{pq-p}\right)^2-\frac{pq-2p'fm}{pq-p}=0, \text{ or } q=1+\frac{(p'-p)^2}{2pp'(1-fm)-p^2}$$

which particular value we shall name q'. It will be observed, when q' exceeds unity, we shall have,

$$2pp'(1-fm)>p^2, \text{ or } m<\frac{p'-\frac{1}{2}p}{fp'},$$

for all applicable cases.

Whereas, for any greater value of u than the one giving q', we shall, from the nature of the function V, which always increases with u, from $u=0$ to $u=1$, have

$$q>1+\frac{(p'-p)^2}{2pp'(1-fm)-p^2}, \text{ or } \left(\frac{pq-p'}{pq-p}\right)^2-\frac{pq-2p'fm}{pq-p}<0.$$

Consequently, the values of x and a becoming imaginary, it would be useless to continue the substitutions of u.

48. Moreover, this limit of u corresponding to q', and which we shall likewise call u', can be obtained directly by an equation of the second degree,

$$\frac{1+u'}{\sqrt{1+f^2}+\sqrt{u'^2+f^2}}=V'=\sqrt{\frac{q'f'}{\delta'f}},$$

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which gives, neglecting the negative value $u' = -1$, a value entirely foreign to the equation,

$$u' = \frac{2V'\sqrt{1+f^2} - 1 - V'^2}{1 - V'^2},$$

an expression, however, which can only be adopted when its value will be below unity, and when that of $V' = \sqrt{\frac{q'f'}{\delta' f'}}$ is not greater than the ratio of 1 to $\sqrt{1+f^2}$; for the substitutions must cease with the value of $u = 1$, which renders a infinite.

49. This discussion will serve in a great degree to diminish the necessary calculations in preparing the auxiliary table of the values of x and a, which is the table mentioned in article 31; it will also permit us to discover, *a priori*, the law followed in each case by the first of these values, and particularly to detect, for the general case, the conditions under which the thickness of x is susceptible of a finite limit, even when the height of the load converges towards infinity.

The quantities p', p, f, and m, always preserving finite values, we see by the general expression for x (47), that it can only take the form of $\frac{1}{0}$ for the single positive value of u, which renders $pq - p$ nothing, or q precisely equal to unity, that is to say,

$$V^2 = \frac{f'}{\delta' f}, \text{ or } V = \sqrt{\frac{f'}{\delta' f}}.$$

50. This same value of u necessarily being under the limit considered in article 48, it is evident that the substitutions should not cease with it; but as, in its passage through infinity, x will have changed its sign, one of the roots of the equation (w) will no longer represent values of the thicknesses sought for, whilst the other will continue to give appropriate and positive values of x. Moreover, we can easily take this circumstance into consideration, by observing that the condition, $q = 1$, will only render one of the roots of this equation infinite. Its term in $(x - m)^2$ disappearing, if x is finite, the equation will simply give

$$x = \frac{p(1 - 2fm)}{2f(p' - p)},$$

for the other root, which will, in effect, preserve a finite and positive value as long as p' exceeds p, and m is not greater than $\frac{1}{2f}$.

Discussion relative to the limit of thickness, and to the influence of the choice of a coefficient of stability.

51. Let us return to the general question, and investigate what is the condition in order that the thickness of the wall may preserve a

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finite limit, even when the height of the load converges towards infinity. We have seen (49) that the value of x only takes the form $\frac{1}{0}$ when the quantity q, or $\delta' \frac{f}{f'} V^2$, passes through unity in the interval comprised between $u=0$ and $u=1$, which last value of u, in all cases, answers to an infinite load. Now, the function

$$V^2 = \left(\frac{1+u}{\sqrt{1+f^2}+\sqrt{u^2+f^2}}\right)^2,$$

increasing in a continuous manner in this interval, and its greatest possible value answering to $u=1$, for which it simply becomes

$$V^2 = \frac{1}{1+f^2}, \text{ which gives } q = \frac{\delta'}{f'} \frac{f}{1+f^2},$$

it results from it (47) that the thickness of a revetment will necessarily preserve a finite limit, if this greatest value of q should be below unity; that is to say, in all cases where we shall have

$$\frac{\delta'}{f'} < \frac{1+f^2}{f},$$

but the minimum of the expression $\frac{1+f^2}{f}$, corresponds to the case of $f=1$, when the natural slope of the earth is 45°, and its value is then reduced to 2. In fine, the thickness of a revetment will preserve a finite limit in all cases arising in practice, if we constantly have

$$\delta' < 2f', \text{ or at the most } \delta' = 2f',$$

and when it is otherwise, the thickness will converge towards infinity, at the same time with the height of the load.

52. We perceive what an important influence the choice of a coefficient of stability may exercise in the actual case upon the determination of the thicknesses of revetments, relative to very great heights in the superincumbent earth, and how necessary it becomes to fix upon correct data in regard to it, if we do not wish to risk running into dimensions which would beyond measure exaggerate the expense, or which might seriously compromise the solidity of the work. In particular, the coefficient of stability $\delta' = 2.38$, which M. Audoy obtained by taking, after M. Boistard, $f' = 0.75$, this in general giving $\delta' = 3.17f'$, would lead us to thicknesses which would increase rapidly and indefinitely with the height of the load of earth. The same conclusions will, *a fortiori*, follow from the value which we shall obtain for δ', if we take into consideration the weight of the earth which acts upon the summit of the wall, and to which this officer paid no regard; for, in going over his calculations on this hypothesis, and in continuing to take the profile of Vauban as a point of comparison, and supposing (15): $f=1, p=\frac{2}{3}p'$, we shall find $\delta' = 3.3f'$, in the place of $3.17f'$, or $\delta' = 2.475$, in place of $\delta' = 2.38$.

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We do not think that, in any case, such a number should be adopted for calculating the thickness of revetments, nor even 2.3, to which M. Audoy had definitely reduced the coefficient of stability, relative to sliding. We shall soon explain the motives for it; but, usage having in some degree given importance to the considerations which served to obtain it, we believe it proper to examine in itself the influence of the magnitude of the ratio $\delta' : f'$, upon the progress of the values of the thickness e, on the particular hypothesis of $f = 1$, $p = \frac{2}{3}p'$.

53. The maximum value of $\delta' : f'$, which allows these thicknesses to preserve constantly a finite value, being then equal to 2 (51), and that given by the ordinary revetment of Vauban being, as has just been said, 3.3, we have successively calculated (147) on the hypothesis in question, tables of these same thicknesses relative to the values $\delta' = 2f'$, $\delta' = 3.3f'$, which we shall consider as limits, and to their arithmetical mean $\delta' = 2.65f'$, so as to be able to form clear ideas upon the true influence of these essential given quantities on the question, and upon the limit of the heights of loads, which, in each case, will require greater thicknesses to those which answer to the hypothesis of rotation, and to a coefficient of stability, $\delta = 1.912$ (18.)

These partial results are found united and arranged for comparison in the following general table, where we have also introduced an extract from that of number 34, relative to this same hypothesis of rotation, as well as the thicknesses given by the formula:

$$e = (0.2\,a + 0.1)\,H + 1.225 \text{ metres,}$$

which reproduces, for vertical walls and the case of sliding, the stability of the profile of Vauban, without counterforts, according to the principle of transformation which will be explained in the following chapter.

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Comparative Table

of the thicknesses of Vertical Revetments supporting high superincumbent loads of earth, calculated for earth and masonry of mean densities, on the hypothesis either of rotation or of sliding, and in attributing different values to the coefficients of stability and friction, relative to the latter hypothesis.

Values of $a=\frac{h}{H}$	From the rule of Vauban.	On the hypothesis of the rotation, the berm being			From the equations relative to sliding						
					1st hypoth of $\delta'=3.3f'$, berm being		2d hypothesis of $\delta=2.65 f'$, the berm being			3d hypoth. $\delta'=2 f'$, berm being	
		Zero.	equal to 0.2 H	equal to thickn'ss e	Zero	equal to thickn'ss e	Zero	equal to 0.2H	equal to thickn'ss e	Zero	equal to thickn'ss e
	metres										
1.0	0.30H+1.23	0.61H	0.54H	0.41H	0.57H	0.39H	0.42H	0.37H	0.31H	0.31H	0.23H
1.1	0.32H+1.23	0.63H	0.56H		0.61H		0.45H	0.40H		0.32H	
1.2	0.34H+1.23	0.65H	0.57H		0.65H*		0.47H	0.42H		0.34H	
1.3	0.36H+1.23	0.68H	0.59H		0.68H		0.50H	0.43H		0.35H	
1.4	0.38H+1.23	0.70H	0.60H	0.42H	0.72H	0.42H*	0.52H	0.45H	0.33H	0.36H	0.25H
1.5	0.40H+1.23	0.72H	0.61H	0.42H	0.75H	0.42H	0.55H	0.46H	0.34H	0.37H	0.26H
2.0	0.50H+1.23	0.80H	0.66H		0.94H		0.68H	0.54H		0.43H	
3.0	0.70H+1.23	0.89H	0.72H	0.44H	1.35H	0.48H	0.87H	0.68H	0.38H	0.51H	0.29H
3.2	0.74H+1.23	0.91H					0.91H*				
3.5	0.80H+1.23		0.74H					0.75H*			
4.0	0.90H+1.23	0.96H	0.76H		1.76H		1.04H	0.81H		0.56H	
5.0	1.10H+1.23	1.00H	0.78H		2.18H		1.20H	0.93H		0.62H	
10.0	2.10H+1.23	1.11H	0.84H	0.45H	4.44H	0.52H	1.92H	1.45H	0.42H	0.75H	0.32H
15.0	3.10H+1.23	1.15H	0.86H		6.99H		2.95H	2.36H		0.83H	
20.0	4.10H+1.23	1.17H	0.88H		9.79H		4.90H	4.11H		0.85H	
30.0	6.10H+1.23	1.19H	0.89H	0.46H	16.24H	0.54H	8.94H	8.80H	0.43H	0.90H	0.33H
50.0	10.10H+1.23	1.23H	0.92H		32.42H		17.35H	17.30H		0.93H	
Infin't	Infinite	1.24H	0.93H	0.46H	Infinite	0.55H	Infinite	Infinite	0.44H	1.00H	0.33H
1	2	3	4	5	6	7	8	9	10	11	12

Principal Consequences.

54. Here, again, the length of the calculations has constrained us to leave incomplete the part of this table which relates to revetments with berms equal to a fifth of their height; but, for the particular object in view, it was sufficient, as will be seen, to treat carefully the case where the ratio of δ' to f' attains its mean value 2.65, and which shows that the berm may, in the case of heavy loads, exercise a very appreciable influence in diminishing the thicknesses of revetments, as also happens on the hypothesis of rotation.

In effect, if we at first compare the numbers of the eleventh and twelfth columns, relative to $2f'$, the smallest of the values attributed

to δ' in the case of sliding, with those which respectively correspond to them in the third and fifth columns, relative to rotation, and to 1.912 as a coefficient of stability, we at once perceive that the thicknesses for all widths of berm, calculated on the first hypothesis, are constantly less than those obtained on the second. It is to the latter, then, we should only have regard, particularly if it is ordinary earth and masonry in question. We are, besides, assured by the calculation, that the same circumstances are reproduced for all values of p' greater than that of $\frac{3}{4}p$, which answers to the mean case.

If, then, we compare the sixth and seventh columns, relative to 3.3 f', the greatest value of δ', with the third and fifth, their corresponding ones, which refer to rupture by rotation, we shall see, by the asterisks which designate certain results in the sixth and seventh columns, what are, for each case, or each width of berm, the heights of loads, beyond which it becomes necessary, in the mean case, to substitute the hypothesis of sliding for that of rotation.

In fact, the asterisks of the eighth and ninth columns, relative to the mean value of the ratio $\delta' : f'$, show that this limit of the heights of the load is quite remote; and the want of any asterisk in the tenth column proves, as we had at first remarked, that this same limit does not exist for a vertical revetment with a berm precisely equal to its thickness; but it is necessary not to lose sight of the fact that these relations have only been investigated for earth and masonry of mean density and cohesion.

55. Let us now undertake the comparison of the thicknesses given by the rule of Vauban, which are to be found in the second column of the table, with those obtained on the hypotheses of $\delta' = 3.3f'$, $\delta' = 2.65f'$, $\delta' = 2f'$, which we have just been discussing.

And let us, beforehand, remark, that the first of these thicknesses, which are deduced from a formula of transformation (53) specially referring to the case of sliding, are, for equal values of a, respectively less than their corresponding ones in the second column of the table inserted at number 20, and which result from another formula of transformation relative to the case of rotation; a circumstance which, it may be remarked in passing, justifies the usage, which generally obtains, of only considering this last method of the transformation of the profile of Vauban, since it is the most favorable to solidity.

The constant terms of these same formulas, moreover, rendering impossible all direct and absolute comparison between the results which they furnish, and those of the sixth and twelfth columns of the foregoing table, it will suffice, for the object we have in view, to remark:

1°. That, excepting for demi-revetments, the height H of which is less than four or five metres, the thicknesses (sixth column) deduced from the equation (z) on the hypothesis of $\delta' = 3.3f'$, generally surpass, very much, those of the second column, as given by the rule of Vauban, and also converge towards infinity in a much more rapid manner.

2°. That the thicknesses (eighth and ninth columns) relative to the

hypotheses $\delta' = 2.65 f'$, approximate much closer to it, particularly for very great values of a.

3d. That, in fine, the hypothesis of $\delta' = 2 f'$ (eleventh column) always leads to a less thickness than that given by this same rule.

56. It seems to result clearly from this approximation, that the value 3.3 of the ratio $\delta' : f'$ being that of the pressure to the weight of the wall, together with its superincumbent load, and, consequently, that the coefficient of stability 2.50, which is deduced from it (52) on the hypothesis of sliding, leading to useless exaggerations of thickness, should not be adopted in practice, although they so correctly answer to the particular revetment of Vauban, of ten metres high, covered by an earthen parapet two metres in height. Demi-revetments, established according to the rule of this illustrious engineer, have, in a great number of cases, undergone the test of experience, and constructors have had as much fault to find with the excess of thickness which it furnishes for great loads of earth, or low walls of masonry, as they have had to complain of their insufficiency in precisely contrary cases.

In the second place, the evident harmony which exists between the thicknesses furnished by the rule of Vauban, and the corresponding ones of the eighth and ninth columns of the table, would seem to cause the adoption of 2.65 for the value of the ratio $\delta' : f'$, as it is about a mean of the values, and corresponds to a coefficient of stability δ' nearly $= 2$, if we take (52), $f' = 0.75$.

But, to confine ourselves invariably for coefficients to such figures, considered as the inferior limits of those which give a sufficient preponderance to the resistance of a revetment against the action of the earth, it would be necessary to be certain that the thicknesses furnished by the rule of Vauban are not themselves exaggerated, for the case of $f = 1$ and $p' = 1.5 p$; and it would be necessary to be better informed upon the true influence exercised by the friction and cohesion of masonry at the first instant of its construction.

(To be continued.)

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Friction Dynamometer, or Brake, of M. de Prony, a cheap, simple, and effectual instrument, for measuring the actual power developed by machines. *By* Ellwood Morris, C. E.

It is well known that *friction*, in all machines, consumes or wastes, more or less of the motive power, and that it may, at will, be so augmented, as to consume the whole power of a prime mover; thus by gearing to any steam engine, or other motor, a train of wheel work of sufficient dimensions, and extent, it would be possible, so to multiply the friction of the moving parts, as to use all the power developed by the motor, and leave none for application to useful purposes.

This must be so evident upon reflection, that further illustration seems unnecessary, and it follows, consequently, that in any case where the friction produced, consumes the whole power of the ma-

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chine; if the amount of that friction could be, by any process, correctly ascertained, it would furnish an accurate measure of the power of that machine; *for the retarding force, which consumes the power of a motor, must be an accurate meter of that power.*

M. de Prony, a very distinguished French Engineer, (in the year 1821) was the first to realize, from similar reasoning, and to put in use, a cheap and simple instrument, which should at once, *consume the power of a motor, and measure the power so consumed.*

The simple form of the *Brake*, originally devised by M. de Prony as a Dynamometer, has been occasionally modified by other engineers, to suit the particular circumstances of the motors, by them subjected to experiment.

Capt. Arthur Morin, of the French Artillery, (a mechanical philosopher who is fast acquiring a well deserved celebrity) has given a lucid description of the Brake, or friction Dynamometer, used by him in an admirable series of experiments made between the years 1828 and 1835, upon water wheels of large size, then actually driving various heavy works in France.

A detailed account of these experiments was published at Metz and Paris, in 1836, under the title of "*Expériences sur les Roues Hydrauliques a aubes planes et sur les Roues Hydrauliques a augets.*"

M. Morin in that publication, has briefly but explicitly, developed the theory of the "*Frein Dynamométrique,*" or *Brake Dynamometer* of M. de Prony, and has also given some particular directions for its use; this part of the work referred to, we have in substance translated below, for the information of our readers, and we shall follow it, with some observations, relative to a recent application of Prony's Brake, to measure the power of a motor in this country.

Remarks of M. Morin, on the Brake, or Friction Dynamometer, of M. de Prony.

[TRANSLATED.]

I. *Description of the Brake with a movable ring.*

"The construction and arrangement of the Brake dynamometer, which M. de Prony first applied to measure the useful effect of motors, is well known to mechanicians; but I believe, I ought nevertheless, to describe briefly that which I lately used, and of which I have borrowed the chief forms, from a German Engineer, M. Egen, who has published on the same subject, a collection of very interesting experiments.*

The apparatus is composed of an annular collar of cast iron, (see the annexed figures, 1 and 2;) this collar is in two parts, united at *b*, *b*, by ears, with bolts and screws.

The inner diameter of this collar is $31\frac{49}{100}$ inches, which allows it to be placed on the large shafts of wheels; its thickness in the middle,

* **Experiments made upon the Hydraulic Machines of Westphalia, by order of the Prussian Government, in 1828 and 1829, and published at Berlin in the German language, in 1831.—Tr.**

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and on a breadth of $6\frac{30}{100}$ inches, is $1\frac{19}{133}$ inches; but practice has shown me that this was, perhaps, insufficient, as I will mention further on.

Fig. 1.

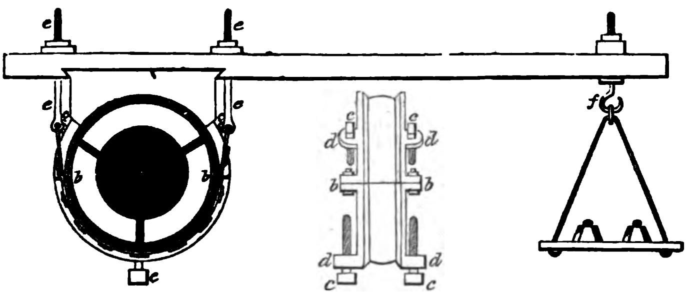

Fig. 2.

On the sides the collar is strengthened by a rim or flanch of $1\frac{19}{100}$ inches projection; intended to render it more rigid, and to hinder the friction pieces from escaping laterally."

II. *Manner of centering the ring or collar of the Brake.*

"The outer surface of the throat was turned with care, so that it answered to centre it relatively to the shaft on which we set the collar, in order to obtain a cylindrical surface exactly concentric to this shaft. It is for rendering this operation certain, and easy, that six large screws, *c c c*, square on the head, are symmetrically disposed on the exterior of the ring, and traverse ears *d d d d*, which serve them to screw by.

The ring being established, and joined on the shaft, we see that by suitably manœuvring the centering screws, it will be very easy to adjust the outer surface. This operation, being very important for the success of the experiments, it is indispensable to make it with the greatest care.

The screws, *c c c*, have about 10 inches of their length filleted, or cut with a thread, which answers for most cases; nevertheless if we wish to operate on a shaft of less than 17 inches in diameter, they will be too short; but we remedy this inconvenience by making the screws to press on intermediate wedges of sufficient thickness. This has no reference to shafts of cast or wrought iron, on which we cannot fix this apparatus without mounting it previously, on a cylindrical or prismatic tube of sufficient size.

We shall be able therefore easily to centre the collar, but the effort which tends to make it turn, with the proper motion about the shaft, being frequently very great, the screws would be likely to be bent, or to furrow the surface of the shaft if it were of wood; to avoid these inconveniences, it is necessary, after the centering, to wedge up strongly, the collar on the shaft, by the aid of wedges, disposed, two and two, so that their outer faces, may be always parallel to the axis.

Three or four pairs of wedges thus arranged, and suitably fastened, suffice for fixing the collar solidly, but it is necessary to take care

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and strike little by little, and turn by turn, in order not to make the annular surface take an eccentric curvature; this will require, I believe, that this part should have a greater thickness than that of $1\frac{19}{100}$ inches which I have given it, and which nevertheless has always been sufficient by taking the proper precautions."

III. *Articulated chain of Pressure.*

"The collar being thus mounted concentrically on the shaft, we surround it by an articulated friction band, composed of eight plates of sheet iron $\frac{19}{100}$ths. of an inch thick, by $3\frac{94}{100}$ inches broad, joined or hinged, together, by bolts of $\frac{19}{100}$ to $\frac{24}{100}$ths of an inch in diameter; and the chain is curved to follow a radius of curvature, a little greater than that of the collar, to the end that the angles of the articulations may be able to receive the grease and other bodies, which may get between the rubbing surfaces.

By this arrangement, we obtain on the surface of the collar, a more systematic division of the pressure, than with a simple band of strong sheet iron; the articulated chain is terminated by two half links strengthened in the upper part, and forming the females of the hinge, for receiving the two plates, and bored parts of two large bolts, *e e*, of $23\frac{6}{10}$ inches long, by $1\frac{19}{100}$ inches in diameter, to which they are joined by small bolts of $\frac{59}{100}$ths of an inch in diameter.

IV. *Lever of the Brake.*

"The bolts *e e*, traverse perpendicularly a piece of pine of $5\frac{19}{100}$ to $7\frac{87}{100}$ths inches square, in the largest of the upper part, (according to the power of the motor examined,) which piece forms *the arm of the lever of the Brake;* the bolts *e e*, are furnished with screws, and large nuts. The under side of the arm of the lever of the brake, receives, by notching, a cushion of *hard wood*, which rests on the collar by a cylindric part concentric to the surface; one or more holes pierced through the lever and the cushion, permits the pouring of oil for lubricating the surface of the collar.

At the extremity of the lever is a superior hook *f*, for a scale, or box, where we place the weights, which form the load of the brake.

It is proper that this hook should have two screws, the one above, the other below, or one screw above, and the projection below, between which the lever may be fastened, so that during shocks, the suspension may not be deranged.

The essential parts of this brake are composed, then, of *the collar, the chain, the bolts, the cushion, the hook,* and *a key or wrench,* for fastening the screws, the whole weighs no more than 440 to 550 lbs.

This apparatus is therefore sufficiently portable, so that a constructor of machines, has in it that which will enable him to measure the power of established motors, or to tell that of those which he has to put at work.

It seems to me very desirable that its use should become familiar to all practical men, for it will furnish them, on the one hand, with certain data for the establishment of projected works, and on the

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other, it will certainly avoid disputes, concerning the effects of motors."

V. *Mode of using the Brake Dynamometer.*

"To insure the success of the experiments, and to avoid the dangers that they may offer, induces me to give some instructions concerning the mode of making use of the brake dynamometer.

It is proper at first to examine if the wheel on which we wish to operate, is centred relative to the external form, and to the coincidence of its centre of gravity, with its axis of rotation.

It will be necessary then, to restore the buckets to a good state, and cause them to have the same play in relation to the sweeps of arrival and escape, and to the walls; then if the wheel is not in equilibrium about its axis, which we may easily observe, we add counterweights interiorly on the proper side to re-establish the equilibrium.

That done, we will visit the gudgeons and cushions, we will grease them properly, and we satisfy ourselves, that there is no friction from projections against the ends of the shafts or of the gudgeons.

The brake being adjusted as we have mentioned, we will place the lever in a horizontal position, then we will arrange in front and rear of the shaft, the beams or points of support, which in allowing it above and below this position, a play of 2 or 3 degrees, limits the oscillations in an invariable manner; this disposition which is much preferable to the ropes, or detaining chains, sometimes employed with the same design, will avoid all the dangers which might be occasioned by the accidental increase of the friction of the articulated chain, and of the collar, in consequence of which the lever would be raised up, and tend to be dragged around with its load, in the general motion of the wheel.

It has other advantages, in giving to the experiments sufficient precision, if we consider the lever of the brake, as being really in equilibrium, when it oscillates lightly between its two supports.

It is necessary, moreover, to be satisfied that the inertia of the masses in motion does not develope, during the continuance of the experiments, a power sufficiently great to make a sensible impression on the results; and we will arrive at it by counting, at many trials, the length of time necessary for a certain number of revolutions. When this shall be constant, we will be certain that the motion is uniform, or, at the least, regular, and that, for the interval considered, the total quantity of work developed by the inertia must be null.

The apparatus being mounted, the experiments are easily cast, and in very little time; we ought always to profit by this facility to make numerous series, corresponding to the different openings of gate, and heads of water, under which the machine can act.

Finally, in each series it will be proper to make the load vary progressively from zero, or the proper weight of the brake, in relation to the distance of the point of suspension, up to that which stops the machine, or, at the least, as near to this last as we can, without danger.

We shall easily determine, also, by experiment, the velocity under which the motor acts the most advantageously."

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VI. *Limits of the power which the Brake can equilibrate.*

"The dimensions of the brake which I have described above, are such that it could be applied to measure the useful effect of a great number of motors. Nevertheless, as the pressure of the chain, and, of course, the friction against the collar, ought to augment with the power of the machine, or the quantity of work measured, it attains, in some cases, a superior limit, that cannot be passed without the surfaces of contact abrading themselves; this, besides the inconvenience of injuring the apparatus, will have also that of depriving the results of the precision desirable, by producing shocks.

It will be proper, then, not to expose it thus, and, in cases where we shall have to measure the work of motors of great power, by placing the brake on shafts having a small velocity, we shall be able to determine the diameter of the collar, by the aid of the following observations.

In all the experiments where the brake described above was employed, I have always noticed that, in spite of the employment of unguents of oil, or hog's lard, the chain and the jaw abraded, whenever the friction at the circumference required to be from *one to one and a fifth tons,* (*or say one-fourth of a ton per inch of the breadth of the friction band,* Tr.) in order to equilibrate the force of the motor.

By estimating, then, about the maximum power that the motor can exercise under the most favorable circumstances, we shall be able easily to determine the radius of the jaw, so that the friction which will serve to measure this maximum power, never reaches the limit value that we have indicated above. How far we may deviate, is, moreover, evident by the following calculation, which establishes, at the same time, the theory of this apparatus."

VII. *Theory of the Brake Dynamometer.*

"When the brake dynamometer is mounted and fixed, (on a water wheel shaft,) so that the lever and load shall be held in equilibrium, and oscillate lightly between the points of support, whilst under an opening of orifice, and head of water both constant, the wheel moves at a uniform velocity, it is evident *that all the available work, or power, transmitted to the wheel, is consumed by the friction of the articulated bridle chain against the collar;* and when we call

P' the mean *disposable power* at the distance R from the axis of rotation,* which, in the case where the brake shall be mounted on the same shaft with the water-wheel, will be the outer radius of this wheel.

V, the velocity at the circumference R.

S, the friction which is produced at the surface of the collar.

r, the radius of this surface.

* This mean power P' is evidently less than that which is transmitted to the extremity of the radius R, (and which we would designate by P,) on account of one part of it being employed to conquer the friction on the axis of rotation: this is the reason why I distinguish P' by the name, *disposable power.*

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Then we shall have, at each instant,

$$P'\,v = S\frac{r}{R}\,v, \text{ or } \qquad P'\,R = S\,r.$$

But, on the other hand, the lever of the brake, as well as its load, being maintained in equilibrium by the friction S, we have, in designating by

F, the total load of the brake;
L, the horizontal distance, from the point of suspension of this load, to the vertical plane of the axis of rotation;

then $F\,L = S\,r$, and, consequently, $P'\,v = F\frac{L}{R}\,v$.

But $\frac{L}{R}\,v$ is evidently the path that would be described by the point of suspension of the load in a second, if the lever moved with the shaft of the wheel.

We see, then, that *the product of the total load* F *of the brake, by the path that the point of suspension tends to describe in one second, measures the quantity of available power transmitted to the shaft on which we have the collar placed.*

We will remark, that, when we shall have estimated approximately, at its maximum value, relative to the most adverse case, the power P', and that the limiting value S shall be fixed at 1 to $1\frac{1}{2}$ tons, (for a brake of this size,) as we have seen above, it will be easy to determine the size of the radius r, to give to the collar of the brake, in terms of these quantities, and of the arm of the lever R of P'."

VIII. *Estimate of the power consumed in the passive resistances*

"The product $P'\,v = F\frac{L}{R}\,v$, which measures the quantity of power, or work, available, is, for the valuation of the useful effect of an established motor, the result most important to be known for industrial comparisons; but in those experiments where its action is to value the construction of a receiver of power, the effects of the action of the water, the influence of the velocity, and of the other circumstances of the motion of the machine, or when we have not been able to place the brake on the same shaft with the wheel, it is necessary, in order to obtain the total power realized by the receiver, to add to this quantity of work $P'\,v$, that which is consumed by the many pieces in motion. In effect, if, by considerations foreign to the mode of action of the water, we have been brought to give to these pieces considerable dimensions and weight, they may consume notable quantities of power, of which the value is entirely independent of the good or bad arrangement of the receiver, and which must absorb a part of that which it really *utilized.*"

Although it appears, from the above translation, that M. Morin, in developing the theory of the *brake dynamometer* by a general equa-

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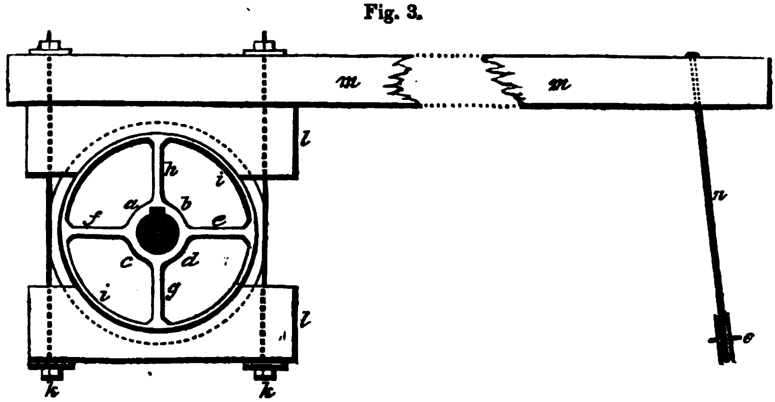
tion, found it necessary to employ algebra, still it is not requisite, in determining, practically, by the *brake*, the power of a motor, to resort, in the computations, to any other than the elementary rules of arithmetic; and it may, therefore, by observing certain simple rules, be correctly employed by any artisan, as we shall now proceed to show.

The writer having had occasion to measure the power of a *turbine* recently erected by Merrick & Towne, of this city, at the Rockland Mills, in Delaware, (and there applied to drive a cotton mill,) determined to use *Prony's brake* for that purpose.

One of these instruments was accordingly made at the Southwark Foundry, and consisted of a *turned cast-iron wheel, or pulley*, four inches broad upon the face, with a ring five-eighths of an inch thick, supported by four arms, and having a flanch about half an inch thick, and say one inch wide, projecting from one margin; the eye of this wheel was accurately bored out $4\frac{5}{16}$ inches in diameter, to fit the cast-iron upright shaft of the turbine, and a key seat being cut in it, opposite to an arm, to correspond to that designed to secure the bevel pinion, the brake pulley was keyed fast on the turbine shaft, in the place of the pinion. Two jaws of hard oak wood, connected with an arm, or lever, were then made to embrace this pulley partially, and, by means of nuts and screws, to press upon it, with any desirable degree of force; to the outer end of the arm, or lever, a cord was attached, which, being conducted in a proper direction over a small, fixed pulley, had suspended from it, by slender hooks, the weights which determined the power exerted by the turbine upon the *brake pulley*, and consumed by it in friction against the wooden jaws, or cushions.

A horizontal view of this arrangement is shown in the annexed sketch.

Fig. 3.



Description of the Brake above sketched.

a, b, c, d, the *eye* of the brake pulley, $1\frac{1}{2}$ inch thick.
e, f, g, h, the *arms* of " " 1 inch average thickness.
i, i, the *ring* of " " $\frac{5}{8}$ inch thick.

k, k, the *bolts*, with their nuts and screws, for tightening the friction jaws.

l, l, the *oak jaws*, 4 inches thick, and about 9 inches broad at the broadest, and 4 inches at the narrowest, part; these jaws were made to press upon the pulley by the screws aforesaid.

m, m, the *arm*, or *lever*, of the brake, about 5 by 6 inches in section, and near 13 feet extreme length.

n, the *cord* by which the weights were suspended, and the direction of which was perpendicular to a radial line 11 feet long.

o, the pulley over which the cord passed.

The shaded circle shows the shaft of the turbine, and the black spot, the key by which the brake pulley was fastened upon it.*

The turbine shaft being vertical, the brake pulley, its lever, &c., acted, of course, in a horizontal plane, and therefore it was that the pulley required merely a flanch projecting from the lower side, as gravity effectually countervailed any tendency of the friction pieces to rise up.

To relieve the brake pulley of the weight of the lever, it was suspended by its middle from the second floor of the mill, so as to vibrate freely in a horizontal plane.

When this brake was first applied by the writer, considerable difficulty was experienced in procuring regularity of friction; for, in consequence of neither the faces of the pulley, nor of the friction jaws, being perfectly smooth, a good deal of jarring took place.

This difficulty, however, was completely overcome, at the suggestion of another, by allowing the brake pulley to run under the action of oil and emery, and with a considerable friction from the jaws, until all the surfaces of contact were ground quite smooth.

The lever was allowed to vibrate in an arc of two or three degrees, between two stops firmly fixed, and, by touching lightly with a wrench, from time to time, *one* of the screws, there was no difficulty in causing it to maintain a central position, with sufficient steadiness.

Following the example of M. Poncelet and of M. Morin on similar occasions, we used *water* as a lubricator, and, while the brake was in action, one or two men with watering pots effectually prevented any burning of the jaws, and supplied a sufficient quantity of water to make the friction regular.

We now subjoin a few of the results obtained by the *brake*, in experimenting upon the abovementioned turbine, for the purpose of showing the simplicity of the mode in which the power developed by any motor tried, is computed by the aid of this dynamometer.

* This brake is upon the plan originally projected by M. de Prony. It was modified by M. Poncelet, in experimenting on his new form of the undershot wheel, in 1826, by substituting, instead of the lower cushion of wood, a broad friction band of wrought iron, tightened by two screws, and embracing *directly* the large wooden shaft of the water wheel. This disposition of the parts may sometimes be the best.

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Some results obtained with the Brake in trying the power of a Turbine.

No. of the experim's	No. of turns of wheel in a minute	Load of the brake in pounds, at the end of an effective lever, or radius of 11 feet.	Space in feet which the end of the effective lever, or radius of 11 feet, tended to describe in a minute.	Horses power of 33,000 lbs. lifted one foot high per minute; actually developed by the turbine.
1	2	3	4	5
1	46	136	$3178\frac{6}{10}$	$13\frac{1}{10}$
2	52	122	$3593\frac{2}{10}$	$13\frac{3}{10}$
3	59	108	$4076\frac{9}{10}$	$13\frac{3}{10}$
4	64	98	$4422\frac{4}{10}$	$13\frac{1}{10}$

In this table, columns 2 and 3 are the data, whence 4 and 5 are easily calculated.

Thus, to obtain the results of column 4, we have given the number of turns made by the wheel in a minute, and the radius of the circle which the extremity of the effective lever of the brake (or perpendicular let fall from the centre upon the direction of the cord) would have described, if it had been free to revolve; this radius, in the above case, was exactly eleven feet in length.

Hence, to find the results which are placed in column 4, in the first experiment of the table, we have $(\overset{\text{feet}}{11} \times 2 \times 3.1416) \times \overset{\text{turns}}{46} = 3178\frac{6}{10}$ ft. And to find, in the same experiment, the horses' power developed, or the result in column 5, we have

$$\frac{\overset{\text{feet}}{3178\frac{6}{10}} \times \overset{\text{lbs.}}{136}}{33,000} = 13\frac{1}{10}\text{ HP.}$$

From these examples it is evident that, having given,

1. The number of revolutions of any motor in a minute, the brake being on the same shaft;
2. The weight in pounds suspended from the brake lever;
3. The acting length of that lever, or perpendicular distance from the centre of motion, to the line of action of the weight;

and having found the circumference of the circle which would be described in one free revolution of the extremity of the acting lever; then the number of horses' power developed by the motor, (or by the shaft on which the brake is mounted,) in any one experiment, or the useful effect of the machine, may be found by the following

RULE.

Multiply together, successively, the load of the brake in pounds, the number of turns of the brake pulley in a minute, and the circumference of a circle of which the acting lever is the radius.

Divide this product by 33,000, and the quotient will be the horses' power required.

Such is the simple process of experiment and calculation, by which the power of any machine may be accurately determined with M. de Prony's ingenious brake dynamometer.

The simplicity and cheapness of Prony's brake, the accuracy of its results, and the ease with which it may be applied to test the power of a motor, recommend it in the strongest manner to the attention of all scientific and practical men, who are interested in affairs of this nature. Tredgold recognized the simplicity and beauty of this meter of power, by recommending a simple Prony's brake, with one cushion of wood attached to the lever, and a friction strap of wrought iron, tightened by a single screw, to be applied to the fly-wheel shaft of steam engines, as the cheapest and best means of measuring the power developed by them; (see Tredgold on the Steam Engine, edition of 1838, p. 270,) and to this purpose the brake has been successfully applied, both in Germany and France.

Already we find, in the late French treatises upon mechanics, long and valuable tables of the exact power required to drive a great number of the machines in common use; these interesting results have nearly all been obtained by means of Prony's brake, and a little well-directed exertion on the part of our numerous practicians, would soon enable us to form tables of the power needed, to impel most of the machines used in the arts amongst us.

It is scarcely necessary to say that such tables, whilst they would be invaluable to constructors of works, would be deeply interesting to all mechanical philosophers, and might be the means of preventing a great waste of money, which is continually occurring, from the erection of motors utterly disproportioned in power to the machines they are intended to actuate; examples of which will doubtless occur to most of our readers, as they exist in every quarter of the country.

M. Morin, in the experiments which he made upon *turbines,* (subsequent to those on other water wheels,) used a brake very similar to that lately employed by the writer; and, in his account of these experiments, published at Metz and Paris in 1838, under the title of "*Experiences sur les Roues Hydrauliques a axe vertical appellées Turbines,*" he describes this brake, and the method of using it, substantially, as follows:

Of the Brake applied by M. Morin to the Turbine of Mullbach.

"This brake was formed by a pulley of (1.25 m.) $4\frac{1}{10}$ feet in diameter, and of about (0.25 m.) $\frac{82}{100}$ of a foot broad at the throat, which had been turned with care, as well as its edges, and was well centred and wedged upon the upper part of the shaft of the turbine, which had not yet received the spur gearing which belonged there."

"The two jaws of this brake were of wood; the length of the lever, measured perpendicularly to the cord to which the charge was suspended, was found to be (2.99 m.) $9\frac{81}{100}$ feet."

"A cord fixed to the wood-work at (6 or 7 m.) $19\frac{68}{100}$ to $22\frac{97}{100}$ feet high, sustained the end of the lever, and a plumb line indicated the

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position which it ought to preserve, while its acting length was perpendicular to the direction of the cord, which, passing over a fixed pulley, sustained the load."

Precautions taken by M. Morin to insure regularity of movement with the above Brake.

"To maintain the surfaces in the same state of humidity, we introduced, near the wheel, the fire engine of the establishment; and a watering pot was suspended above the cushion of the brake, in which a notch was made, whence the water poured on it."

"The men, in working the pump, directed a regular current upon the rubbing surfaces, which were thus perpetually cooled and lubricated to the same degree."

"We obtained, in this manner, such regularity in the action of the brake, that, when under the same charge, it has sometimes moved more than one half hour without suffering the least oscillation, and without any necessity of acting upon the screws."

"In others of our experiments, the oscillations of the lever below the vertical of the plumb line had not exceeded (0.02 to 0.03 m.) $\frac{6}{100}$ to $\frac{8}{100}$ of a foot, either way; and the stay pieces, disposed as a precaution, served only for the moments of interruption."

"We have not used a kilogramme of grease in making all these experiments, and although I already well remembered employing this dynamometrical apparatus with success, I had never seen it move with such perfect regularity."

"Thus aided by these easy and cheap means, I consider as entirely useless superfluities, all the modifications proposed or adopted by divers engineers in the simple arrangement originally proposed by M. de Prony."

Where the shaft upon which the brake is mounted revolves at a very high velocity, some difficulty may be experienced in counting correctly the number of revolutions made in a definite time; and the writer will observe that, in experimenting on the turbine of Moussay, where the speed ran as high as 250 revolutions in a minute, M. Morin found it necessary to cause a spring blade to strike a projecting key at every turn, and then counted their number by *sound.* To count the number of revolutions, we have found it convenient to cut a nick in the shaft upon which the pulley is mounted; this shaft being smeared with oil, and the nick being rounded a little on all its edges, then, by holding a finger upon the shaft, so as to be touched by the nick at each revolution, the number of turns in a minute may be counted by the *touch*, with ease and accuracy.

Either *by touch, by sound*, or *by sight*, there are various modes, which will suggest themselves to the practical mechanic, by which all difficulty in accurately determining the number of revolutions in a given time, may be overcome.

We will now make a few observations relative to the strength proper to be given to *the cast-iron pulley of a brake*, and to the best mode of mounting it, where the shaft of the motor experimented upon

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is of *cast iron*, and admits of its being placed upon the intended seat of a spur, or bevel, wheel.

The brake pulley ought not to be less than two feet in diameter, and should be of the same strength and dimensions as would be required by a cast-iron spur wheel, to transmit the maximum power of the motor, at the minimum speed.

It should, in fact, be a spur wheel, with the teeth removed, the face turned smooth, and having, in addition, either one, or two, projecting flanches, according as it is designed for application either to vertical, or horizontal axes.

The dimensions of a *brake pulley*, upon the above supposition, may very easily be calculated by the well known rules in use among machinists for determining the proportions of spur and bevel gear.

It will be observed that the pulley of the brake used by the writer was much lighter than a spur wheel would have been, to transmit the greatest strain it was employed to measure, or $14\frac{4}{10}$ H P, at sixty revolutions per minute; *it was, in fact, too weak*, and, judging from the symptoms of weakness displayed by it in an early stage of the experiments, it would undoubtedly have broken, had not the precaution been taken to fill the vacancies between the arms with oak plank, neatly scribed to fit them.

The mode of mounting the *brake pulley* upon the shaft of the motor under trial has usually been, as is described by M. Morin; the eye of the pulley being considerably larger than the shaft, (to enable it to fit various arbors,) and wedges being well driven to fill the vacancy; while, with the view of enabling the brake to be easily applied upon any shaft without displacing it, the pulley has usually been made in two parts, and joined with screws, whilst embracing the shaft.

Though this arrangement undoubtedly possesses some advantages, still the writer has found the method of fixing the pulley upon a cast-iron shaft, by wedging, to be so unsatisfactory, as to induce him to think that it is decidedly better, whenever practicable, to bore out the eye of the pulley so as to fit the seat of a spur, or bevel, wheel, and key it fast there with a single key, in the approved manner now used for staking on gearing; and although this mode will require a separate brake pulley for each size of shaft experimented on, still, its steadiness, firmness, strength, simplicity, and the certainty that the pulley will be accurately adjusted in both directions by the quick and simple operation of driving the key, *all combine to recommend this plan in practice.*

Before applying, to the turbine at the Rockland Mills, the brake pulley we have above described, the writer tried one that was made in two equal parts, screwed together at *f* and *e*, (see fig. 3) and of which the eye was about two inches larger in diameter than the shaft; it had *four* centering screws, at the points marked *a*, *b*, *c*, and *d*, and, after being centred, it was wedged fast to the shaft, with iron and wooden keys.

Several difficulties occurred in using this brake pulley:

1. With only *four* centering screws, placed singly, though they enabled it to be easily centred horizontally, it was found impossible to

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bring the brake pulley truly into a horizontal plane, so as to run without wabbling.

2. The moment an experiment was begun, the centering screws rapidly unscrewed themselves by the jar of the machine.

3. The iron wedges, between the eye and the cast-iron shaft, would not hold, and wooden wedges, being tried, failed also:

4. Being nearly of the same dimensions as the other brake pulley, it was too weak.

Though the first, second, and fourth objections admitted of being remedied, by using *eight* screws, placed vertically in pairs, instead of *four*, by using lock nuts, and by augmenting the strength of the pulley, still, as it seemed very doubtful whether or not the third could be so easily overcome, the writer resolved to adopt the other mode of mounting the brake pulley, which, as we have before said, *proved entirely satisfactory.*

As a proof that brake pulleys, of the size of those above referred to, are too weak to sustain a power of $14\frac{4}{10}$ horses, at sixty revolutions per minute, the writer will mention, that, in applying to the last mentioned pulley, (which was mounted with wedges,) a power of about thirteen horses, at a speed of near sixty revolutions, it burst with a loud crash into several pieces, and brought that series of experiments to an abrupt termination.

We will now conclude by again recommending the brake of M. de Prony to the attention of practical men, *as the cheapest, simplest, and most convenient dynamometer that has yet been invented, to measure the power of machines.*

Philadelphia, March 1, 1843.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 163.]

SECOND COURSE. LECTURE IV.—LAYING OUT RAILWAYS.

In the preceding lectures, the subject of the motive power had been much enlarged upon, from its necessarily influencing the manner of laying out a line. Mr. Vignoles said the student may be referred to study, at greater leisure and in detail, the principles laid down in the works of various authors, on laying out both roads and railroads—M'Neill, Parnell, Navier, Tredgold, &c.,—and the rules laid down by them may be taken as sound first principles, though modified at present by the improvement of motive power, and other causes, which could not have been known *a priori.* Railroads have so completely superseded many of the principal roads, and the public convenience has been thereby so much interfered with, that it becomes a matter of importance to run the trains as often as possible, and this becomes a new element in laying out a line of railway. Hitherto this has been done under the impression that the engines would always carry maximum loads, and though it is true that main lines radiating from the metropolis, into which a number of tributaries fall, may be laid out with a view to maximum loads, yet it becomes a consideration

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whether it would not be better, in general, to lay out railways with a view to the trains going often, and with light loads, and thereby to make the gradients suitable to the ground over which they pass. On this subject, Mr. Tredgold has always judged soundly. Seventeen or eighteen years since, he made various calculations on the comparative expense of ascending and descending inclined planes, and of cutting them down to a level; and he states, in his Treatise on Railroads, that it will be much less expensive to follow nearly the undulations of the surface, and "if a few examples (of the comparative expense) be added, it will assist in removing those extravagant notions of cutting and embankments, by which the capital of the country is wasted in unprofitable speculations." But the practice of engineers has been directly opposed to this, although we had almost a daily improvement in locomotive power, affording means of overcoming the difficulties of steep gradients. Before determining upon the inclinations which he will adopt, therefore, the engineer should make estimates of the comparative expense of forming and working flat gradients, and gradients of an inferior description, and it will be found that gradients of fifty, sixty, and even eighty, feet in a mile, may be advantageously introduced, especially where the traffic is not very considerable. And if lines were laid out upon these principles, instead of the traveler being overcharged with the expense of the capital sunk, as at present, he would be charged with the expense of the motive power, which bears a very small proportion to the total amount exacted from passengers. Locomotive power only is scarcely more than ¼d. per passenger per mile, whereas the ordinary charge to passengers is 2d.; and this may explain why railway companies do not lease the working of their lines, for they make most of their profit as carriers, and not as capitalists.

In laying out railways, there are generally two distinctive descriptions of country which the engineer meets with, each of which requires a different description of treatment with respect to his operations. The first is where there is a certain summit, or ridge of country, to be surmounted; the rule in this case will apply both to roads and railroads, viz., to get a uniform inclination, if possible, up to the summit; but, if that be not practicable, to lay out the line in stages, taking care that, having once attained any intermediate elevation, the line does not, if possible, descend again. In a country of this description, there will be much more difficulty in the details than in striking out the first general idea, for it will require the greatest care and patience to lay out the line so as to ascend to the summit at the least possible expense, by winding along the sides of hills, and crossing lateral valleys and ravines to the greatest advantage, &c.

The other description of country is where the extreme points of the line to be laid out are on a level, or nearly so, and the ground varies. In this case his judgment will be principally exercised in determining the general direction of the road, in taking trial levels to determine the line of least cutting and embankment, in avoiding valuable property, and in securing the largest amount of traffic; and in a country like England, which is so full of improvements, gentlemen's seats,

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roads, streams, &c., it is an exceedingly complicated duty to make choice of the best line under such circumstances; but it may be laid down as a general rule, that, in any difficulty, it is always better to incur a positive known expense, which will not entail future liability, than, by diminishing the expense in the first instance, to run the risk of undergoing future loss. Thus, for example, if a line of railway upon a slight embankment should cross a road on the surface of a wet or marshy country, it will be better to raise the road to a sufficient elevation to pass it over the railway, though the height of the bridge and approaches be thereby greatly increased, than, by slightly lowering and passing it under the railway at a greatly reduced expense, to render it liable to be continually laid under water. And these are the kind of circumstances that require so much care and consideration on the part of the engineer, to enable him to judge of the comparative amount of cost and maintenance of the different systems which he can adopt, and to regulate his designs accordingly. Now we might go on thus increasing railway gradients until they approached nearer and nearer to those of a turnpike road, were it not for the difficulty of regulating the descent of them with safety. On a turnpike road, writers have suggested that from 1 in 36 to 1 in 40 is the best slope, because horses may gallop down without danger, and, at the same time, it is a good trotting road upwards. But on railways it is not safe to go down such inclinations as that. Professor Barlow lays down that when the inclination is greater than 1 in 160, all advantage from gravity in the descent is lost, from the necessity of applying the brake, and he has formed tables to show the amount of loss sustained in the ascent; thus, he states that going up one mile of 1 in 100 is equivalent (of course with a maximum load) to going 2½ miles upon a level; but he will not allow that any corresponding advantage is gained in the descent of this, or any plane steeper than about 1 in 180. Now, if this be the case, we must have a totally different set of elements in forming lines of railway from what I have been laying down. But, as has been already stated, this is not the case in practice, for trains can have, with perfect safety, the full benefit of gravity on all descents up to 1 in 100, and the engines seldom carry maximum loads. The same line of argument has been pursued with respect to turnpike roads, where, however, there are many circumstances in operation which do not occur on railways—such as the unsteadiness of horses and coachmen—which influence the question; but the great point to be considered is, whether it is most economical to lay out railways with respect to stationary, or to locomotive, power. On this subject M. Navier very sensibly remarks, that, great rapidity being the characteristic of railways, it has been considered necessary to employ locomotive engines, which system presents an important advantage in being able to increase gradually the number of engines, as the demands of commerce require it; whereas, on the stationary system, it is necessary to provide at once for the greatest amount of traffic that can ever occur. But, in the event of this increase, we have still the means of using light and frequent trains for transporting a heavy traffic over a line of inferior gradients, and reducing the charge of the

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interest of that capital to the public. But, whatever be the description of country which the engineer may meet with, he should, first of all, make, or procure, detailed plans on the largest scale, and upon them lay down a number of surface levels, and from them, as from a model, to find the line of least expense and greatest accommodation. The magnificent Ordnance Maps of Ireland, from their great scale and numerous surface levels, will render the task of the engineer, in that respect, easy, should the long deferred introduction of railways into that country be ever carried.

(To be continued.)

Facts and Observations on Four and Six Wheel Engines.

By JOHN HERAPATH, ESQ.

[Continued from Page 89.]

London and Brighton Railway.—After the long journies I had in the winter, I was in hopes I had terminated my labors. It being, however, the wish of the managers of the *Railway Magazine* that I should go over the Brighton line, I asked and obtained permission of the Company to do so.

Six projects for lines were once candidates for public favor to Brighton—Stephenson's, Cundy's, Gibbs', Palmer's (or the South Eastern), Vignoles', and the one which is now made, Sir John Rennie's. For two successive sessions the parliamentary warfare was carried on. At one time it was calculated that the united parliamentary expenses amounted to upwards of £1,000 a day; and I have heard it said, but with how much truth I do not know, by one of the parties deeply interested, that, including all the expenses and all the prior costs of all the Companies, there was near £300,000 spent on the Brighton lines before the present Act was obtained. I have, however, also heard from others, apparently equally entitled to credit, that not above £160,000 was spent.

Perhaps, in no parliamentary contest was there ever more acrimonious feelings displayed than in this one. Engineers, counsel, solicitors, parliamentary agents, and a legion of witnesses reaped a rich harvest out of the pockets of the subscribers; such a time will hardly ever come for them again.

At length Captain Alderson was appointed by the Government to report upon the best line to Brighton, and decided in favor of this one, as surveyed and proposed by Sir John Rennie. The Act was then speedily obtained, and received the royal assent July 15, 1837. Soon afterwards Mr. Rastrick was appointed the acting engineer, and July 12, 1841, 28 miles of the line, namely, to Hayward's Heath, were opened, and on the succeeding 20th of September, the remainder. Thus, in the short space of about four years, was the land bargained for and conveyed to the Company, and the works, which were said by one of our most experienced engineers never could be executed, finished, and the line in operation for the accommodation of the public and the benefit of the Shareholders.

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Such expedition is highly creditable to the Directors, engineer, and not less to the Proprietors, by whose ready and efficient supplies they were enabled to surmount the difficulties, and complete the undertaking. But, probably, the best commentary on the conduct of all, is the following comparison with the other metropolitan railways:—

Names.	Passing of Act.	Opened entirely	Time.	Length
			ys. mo.	miles
South Western,	July 25, 1834.	May 11, 1840.	5 10½	76½
London & Birmingham,	May 6, 1833.	Sep. 17, 1839.	6 4½	112½
Great Western,	Aug. 31, 1835.	June 30, 1841.	5 10	118¼
Croydon,	June 12, 1835.	June 1, 1839.	3 11½	8½
Eastern Counties,	July 4, 1836.	Not yet.		126
South Eastern,	June 21, 1836.	Not yet.		65
North and East,	July 4, 1836.	Not yet to Cambridge.	5 7	53
London and Greenwich,	May 17, 1833.	Dec. 24, 1838.		3¾
Blackwall,	July 28, 1836.	Aug. 2, 1841.	5 0	3½
London and Brighton,	July 15, 1837.	Sep. 20, 1841.	4 3	41¾

A more creditable proof of industry could scarcely be expected in a work of such acknowledged difficulty. The line nearest to it in difficulty, as a whole, is the London and Birmingham, and that, with the best and most prompt and wealthy proprietary in England took above two years longer, or nearly half as long again.

Before the Act for this railway was obtained, parties for the sake of getting supporters to their various schemes to Brighton, talked of capitals of £800,000 or £900,000, but as soon as it was certain that this line would be carried, common sense dictated to them a more reasonable sum. Accordingly the capital was fixed at £1,800,000, in 36,000 shares of £50 each. By the statements in the R. M. vol. iv, p. 470, it appears that the capital, after deducting £5 per share undertaken not to be called up, is £1,620,000, and that the cost as per last report was £2,568,212 or 1.59 times the estimate. Comparing this with the other finished metropolitan lines, and we have—

Names.	Estimate.	Cost.	Excess per ct.
	£	£	
Birmingham,	2,500,000	5,894,551	135
Great Western,	2,500,000	6,341,326	153
South Western,	1,000,000	about 2,000,000	100
Croydon,	140,000	637,875	355
Greenwich,	400,000	934,774	133
Blackwall,	600,000	1,071,717	79
Brighton,	1,620,000	2,568,212	59

Thus it appears that the line was finished in a less time than either of the metropolitan lines, the Croydon only excepted, and at a far less proportional excess of expenditure. It is usual for the excess to be in proportion to the rapidity of execution. As, for instance, the Croydon was executed in less time than any line, and cost 355 per cent. above its estimate. But the Brighton line finished within 3½ months of the same time, cost only 59 per cent. more than its estimate, though pre-declared impossible.

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I presume the two facts of time and excess of expenditure of this line, which was so ridiculed for its supposed impossibility, is the best answer that can be given to the calumnies which have been heaped upon the administrative and executive departments. The only railway which has approached it in rapidity of execution, has exceeded its estimate nearly six times as much ! !

Description.—This line commences at the Greenwich station at London Bridge, which line it takes for 1¾ miles, then the Croydon for 7 more, and passing Reigate and Cuckfield each about 1½ miles to the east, takes an almost direct southerly course to Brighton, which it reaches in 50 miles and 50 chains. In its length there are three summit levels, namely, one near the middle of the Merstham tunnel, one a little before entering the Balcombe tunnel on the London side, and a third just at the Brighton end of the Clayton tunnel. From London to New Cross, 3 miles, it is nearly level; for 2 miles 50 chains after there is a rise of 52.8 feet a mile; thence to the Croydon Junction, 8¾ miles from London, it is again nearly level; after that, for 8 miles to the middle of the Merstham tunnel there is a continued rise of 20 feet a mile; then another uniform descent for 7 miles of 20 feet a mile to the Horley station, about 25 miles from London; then an ascent for 2¼ miles of 11½ feet per mile, followed by one of 20 feet a mile for 4 miles; after this come 5½ miles of descent of 20 feet a mile, 3 miles of 16¾ feet a mile, which brings us to 40 miles from town. Then follows a rise for a mile of 20 feet, for a 1½ mile another of 16½ feet a mile, and then 3 miles of 20 feet a mile. Hence there is a uniform descent for 4¾ miles to Brighton of 20 feet a mile.

The Brighton line therefore consists of six long inclines, the prevailing gradient of which is 20 feet a mile.

The Shoreham branch is a continued descent from Brighton to very near Shoreham.

This, and the South Eastern Dover line, run together until they come to within a quarter or half a mile of the Red-hill station, that is for 20¾ miles. The part, 12 miles, between the Croydon Junction and Red-hill, will be a sort of common ground for the two Companies, as soon as one half the cost of construction, about £350,000, including interest of capital and other expenses, shall have been paid over by the South Eastern to the Brighton Company. Each party is to keep up its own half of the road, and to run toll free over the other. The part belonging to the Brighton is the first portion after passing the Croydon Junction.

At first sight it would appear that the Brighton Company had the worst of the agreement, as their portion of the ground is the least expensive and the most costly to keep up, being chiefly embankment; but this is not so, as the embankments are chalk. All the risk of finding the money and the anxiety and trouble of construction have likewise been the share of the Brighton Company. But then they have had the advantage of getting the line sooner opened, and the twelve month's profit arising from the use of it; for, had any portion of these twelve miles been incomplete, it would have been nearly tan-

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tamount to having the whole line unfinished. On the other hand, there is no doubt but that the Brighton Company having finished their line, has been a great spur to the South Eastern Shareholders, who at one time appeared very lukewarm towards their undertaking.

Upon the whole, the advantages are pretty equally balanced between the two Companies, and it is quite obvious that the agreement itself has been beneficial to both. It is therefore to be devoutly hoped that its consummation will be effected in harmony and good fellowship between them. Every one who attempts to prevent it, by word or deed, is an enemy to both, and as such ought to be regarded. Questions arising out of the cost of the joint portion are not here contemplated. From the wording of the act it is presumed there can be no material points for dispute, and it is to be hoped the good sense of both parties will not allow minor matters to form cause of dissension.

Could the Companies have made a common station at Red-hill, instead of having two near half a mile a part, it would have been much better for them. As it is, however, the next best thing they can do is to work the whole distance to Red-hill in joint trains. This would save all danger of collision, all perilous rivalry between the men, and, what is of material consequence to the Shareholders of both Companies, nearly one half the expense.

Exclusive of considerations of traffic, such a plan is of more consequence to the South Eastern than to the Brighton Company, inasmuch as the engineer of the former Company having laid his rails at a 4 feet 9 inch gauge, instead of a 4 feet 8½ inch, if the engines are made to a 4 feet 9 inch—which, as being the longer length to run over, it is probable he has—they will travel with more friction and expense on the Brighton rails than they will upon the South Eastern. It will therefore be preferable for him to keep his engines to work on his own line, to which they are better adapted.

Character of the Works.—The works are generally heavy, but are well executed. The Ouse Viaduct, for instance, is a noble and handsome structure, entirely of brick, except the parapet. It is 1,434 feet long, and 96 from the top of the rails to the river. It consists of 37 semi-circular arches, each 30 feet span, built on lofty piers. The parapet is of light Caen stone, and is said to have cost no more than Portland stone. At each end of the viaduct are 4 tasty temples or sentries, which add much to its beauty. The arches are 1½ brick thick, and the engineer has made a considerable saving in the brickwork by employing arches of 30 feet span instead of 60 feet. The beauty of this viaduct, the finest work on the line, and second perhaps to none in the kingdom, is lost to the traveler, and can only be seen in the valley. I have heard that an hotel, gardens, &c., are to be laid out in the neighborhood.

I had an opportunity of examining this structure in company with several professional gentlemen, who one and all much admired its design and execution. With the closest attention not the slightest distortion was detected.

Having its dimensions, I therefore made an approximate calculation of what ought to be its cost according to other similar constructions I

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had seen, which came out from £70,000 to 80,000, but I heard then that £62,000 was much nearer the mark, upon which one of the engineers, Mr. Blackmore, observed to me, "then it has been built a great deal too cheaply."

Odium has been attempted to be thrown on the engineer for not using in the Red-hill and other embankments the chalk excavated on the other parts of the line. If he could have commanded this chalk he would have been mad not to use it. But the fact is, when it was wanted it could not be had, for the best of all reasons, that it was in the unexecuted tunnels, and on the wrong side of them; and had he made the embankments wait for this chalk, the line could not have been finished under 10 years instead of 4½.

The stations, 11 in number, are neat and simple buildings, upon which it is quite evident not too much money has been laid out. At Brighton, however, the station is large and capacious, and contains an excellent suite of rooms, well arranged for the administrative and executive departments. The carriage shed is divided into two compartments, one for the *London* and the other for *Shoreham* traffic. This shed is one of the most beautiful, light, and airy structures of the kind I ever saw. It is 295 feet long and 166 feet wide, and built upon a gentle curve, which gives to its trussed iron roof a very pleasing appearance. I am told the roof of this shed cost about £5,000. The shed is completely open at the sides, the offices standing across the end, and the roof is supported on numerous iron pillars. The curved girders supporting the trussing of the roof are not cast in one piece from column to column as is usually done, but the spandril forms the centre of the girder, whose ends abut in the middle of the arch. By this means there is no lateral thrust upon the iron columns; the pressure is vertical, and the stress on the girder thrown where space affords the best opportunity for giving it strength, namely, at the spandrils.

The trussing of this roof, though it appears complex, is simple, light, and ingeniously contrived. Almost all the forces are tensile, and the roofing, therefore, composed chiefly of braces. Where there are struts, they are chiefly tubular, and of course light and strong.

At each station there is an additional pair of side rails on each side. As soon as a train enters this siding, the switch is closed, and no runaway engine or careless fellower can, by any possibility, run into the standing train, but must shoot ahead. Danger, then, from such an unfortunate occurrence as happened at the junction of the North Midland and York and North Midland, is not avoided, but absolutely prevented. This is a plan of the engineer.

There are five tunnels reckoning from London, the Merstham, 1,830 yards long, and 17 miles from London; the Balcombe, 1,139½ yards long, and 32 miles from town; the Hayward's Heath, 248½ yard long, and 38 miles; the Clayton, 2,256½ yards long, and 44 miles; and the Patcham, 491¾ yards long, and 47½ miles from London. Of these tunnels the Merstham has a summit level about the middle of it, and dips, therefore, both ways; the Balcombe commences near the next summit and dips towards Brighton; the Hayward's Heath dips

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in the same manner, towards Brighton; the Clayton terminates near the third summit level, and dips towards London; and the Patcham dips towards Brighton.

I had an opportunity of walking through the Balcombe tunnel with Mr. Rastrick, the engineer-in-chief, who was anxious to afford me the best opportunity he could to inspect it; Mr. Blackmore, engineer of the Newcastle and Carlisle, and several other gentlemen. We were all struck with the difficulties the engineer must have had to encounter with the water in some of them. Before he could proceed with his work he was obliged to run drift ways of from a quarter to half a mile, and build culverts, equal to our London sewers, to carry off the water. In some of the shafts garland gutters are run round them, for the purpose of catching the water and conducting it to pipes leading to the main culvert beneath. To prevent the wet also from falling upon the rails and trains, lead sheeting across some parts of the roofs of two or three of the tunnels is put, which conveys the water down pipes by the sides into the drains.

These lead sheetings have occasioned curious mistakes to be made by some persons, who have run away with the notion that they were used as props to support the arches. Poor props, indeed, lead would be for tunnels.

In riding through these tunnels upon the engine, I was induced to believe that they were more than usually dry, and it was not until I had an opportunity of walking through one of them, that I could form any idea of the trouble that had been taken to render them so.

The bricks with which they are built are all of the best and hardest kind; the arches are laid in cement.

The curves of these arches are ovals, with the longer axis upwards and the shorter across the tunnel, at some feet above the level of the rails, the segment apparently cut off by the ground forming the invert; for I understand they have all inverts. These figures have a pleasing effect. About every 200 yards, in each side of the tunnel we walked through, are spacious recesses, of some 15 feet deep by perhaps 6 wide and 8 high, called sanctuaries, for the purpose of retreat for the workmen from the trains, should two of them meet in a tunnel, and also as a provision for the safety of passengers in case of accident or detention in the tunnel. This, though it may never be wanted for passengers, is a very prudent precaution.

I noticed that in every case the engineer has made his tunnels straight, and put his curves before and after them. By this expedient any obstacle is immediately seen on entering a tunnel, and of course guarded against. All the long tunnels are lighted with gas or oil lamps, which, though but of little benefit to the passengers in their transit, would be of considerable utility in case of accident. They are also thought to be serviceable to the engine drivers by illuminatting the rails before them for very long distances, but I had no means of proving this.

All the entrances to the tunnels are very simple and neat. That, however, on the London side of the Clayton tunnel is a beautiful exception. It consists of a very pretty facing of brickwork and stone,

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a castellated parapet, and a neat octagonal tower on each side of the tunnel entrance, with apartments within them for the policeman. Placed in the midst of a deep cutting, these towers, with their old fashioned loop holes, present a formidable and menacing appearance to intruders.

During my several trips on the engine right through the line, and two special trips over portions of it, I paid particular attention to the cuttings. They are in certain places steeper than I have seen them upon almost any other line. But the material the engineeer had to cut through seems to justify him in the course he has adopted. For example, the cutting in the Shoreham branch, near Brighton, is through a chalk of so shaky a character that one might have been afraid to let it stand at less than ¾ to 1, yet it has now stood for two years at nearly as steep an inclination as the best on the line. The principle apparently followed was to make the slopes in the same cutting according to the material he had to deal with. In the deep cutting on this, the London, side of Merstham tunnel, for a considerable height the chalk is hard and solid, and the slope cannot, I should imagine, be more than 1 to 6, but higher up, where its character changes, it is rounded off much more obliquely. Had he not studied the character of the soil, and had he made the whole cutting of one uniform slope, such as the upper strata required, I hesitate not to say that this cutting could not have been made for at least double the quantity of material and double the expense.

It is by this close adaptation of his works to circumstances, and effecting savings where he could, which have enabled him to be less sparing in difficulties on other parts of the line, and yet keep the whole cost so much nearer the estimate than others have done. With some of his tunnels he must evidently have had a good deal to contend with, and his patience and skill must have been not a little tried.

The rails (75 lb. rails) are laid chiefly on cross sleepers three feet apart, but in one or two places I observed stone blocks, and on the Ouse viaduct longitudinal bearings. The greater harshness of these bearings in changing from them to cross-sleepers, or *vice versa*, though they have two feet of ballast and mould under them, was very apparent.

Trains and Staff.—From end to end the trains work very well and keep their time very correctly, but in some of the intermediate stations they are not so accurate. I have known them five and near ten minutes out, and yet they have arrived at the terminus, without any sensible hurrying, to a minute. A remedy might easily be made by a little alteration in the time-bills. It appears to me that there has been some misapprehension in framing these time-bills. Thus, from London to Croydon, all heavily up hill, 23 minutes are allowed, while from Croydon to London there are 30 minutes. Again, from Hayward's Heath to Brighton, the time is 30 minutes, but from Brighton to Hayward's Heath 24 minutes. The same happens between other places. I have no doubt this discrepancy is not the effect of accident, but I cannot see the utility of it; and the practical advantage, as far as my observations have gone, has not presented itself to me.

Their engine drivers are, from all that I have seen, a sober and

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steady set of men, and such as well understand their business. The entire staff of the Company is indeed a very good one, exceedingly attentive to their duties, and under good discipline. It is not by their attention on the regular trains that I judge of them, but I have had other opportunities of observation, and I invariably found them at their post. Though I was a fortnight backwards and forwards on the line, I am not aware that I met with one churlish, inattentive policeman, conductor, engine-driver, or porter. In fact the Directors are generally so much about the works, and watching the operations so closely, that it would be a great risk for a man to be uncivil, or for a moment off his guard.

Traffic.—With respect to the traffic, to use an old hacknied phrase, "it is yet but in its infancy." If this line follows the example of the London and Birmingham, the Grand Junction, and Liverpool and Manchester, it will go on rapidly increasing for the next two or three years, and then will become nearly stationary, or, if not, its increase will be gradual and uniform.

(To be continued.)

Physical Science.

The late Eclipse..

At the meeting of the Academy of Sciences, on the 22d ult., M. Arago made his promised communication, which has been so anxiously expected, relative to the eclipse of July 8th, as observed by him and other astronomers at Perpignan. We take our report from *Galignani:*—

"M. Arago began by stating that the object of himself and the gentlemen associated with him in the observations at Perpignan, was not so much to verify the accuracy of the calculations as to the precise moment at which the eclipse was to occur, as to determine as far as possible some undecided opinions as to the nature and character of the heavenly bodies on which our earth depends for light and heat; but, being provided with the means of ascertaining the exact moment of the eclipse, they did not, of course, neglect to record it. M. Arago expressed his surprise at having seen it stated by some observers that the phenomenon occurred precisely at the time predicted; for, according to his observation, it did not take place until from 30 to 40 seconds later than the prediction. This error of calculation, he observed, might appear to many to be too trifling to deserve notice, but, in his opinion, it was inconsistent with the progress made in astronomy, and it would be necessary for the honor of the science to trace its cause and prevent its repetition. The learned academician then proceeded to communicate the result of his observations on the halo which appears to surround the moon after the entire disappearance of the sun, and which modifies the darkness occasioned by the eclipse. Plutarch says—'The moon, in an eclipse of the sun, allows a portion of the sun's light to extend beyond her own edges, and thus total darkness is prevented.' The lunar halo is more particu-

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larly described by Plantade and Clapiés in their observations of the eclipse of 1706. 'As soon as the sun was wholly eclipsed,' say they, 'the moon appeared to be surrounded by a very white light, forming round the disk of that planet a halo three minutes in width; within this limit the light was the same throughout, gradually failing, and at length dissipating itself in darkness.' The width of this luminous appearance, however, varies according to the eclipse. In 1719 Halley found an extent of two minutes and seven seconds; in 1806 the observation of an astronomer in America gave six minutes. At Perpignan, on the 8th of last month, the width was three minutes and thirty seconds, and it did not vary during the different phases of the eclipse. M. Arago had recommended to his colleagues to make it an important point to ascertain whether the halo had its centre on the sun or on the moon, the existing opinions on this question being of a conflicting nature. Halley and Lonville have affirmed that the centre of the halo coincided with that of the moon; whereas, according to Maraldi and Ferrer, the centre is always that of the sun. The astronomers of Perpignan report that the opinion of Halley and Lonville is the correct one. They measured the luminous coronet with the greatest care, and found it equal on both sides, which led them to conclude that the white aureola, which extends beyond the obscured body of the moon, is not produced by the sun's atmosphere, and is simply a phenomenon of luminous diffraction. The serpentine lights observed on the surface of the moon in 1715, by Halley and Lonville, and which the latter regarded as lightning arising from storms in the atmosphere of the moon at the moment of the eclipse, were not seen at Perpignan. Some meteors, or shooting stars, were, however, observed. It is not improbable, therefore, that the serpentine lights noticed by Halley and Lonville were meteoric appearances brought by chance over the perspective of the superposed bodies. The Toulouse astronomers, in their account of the eclipse of July 8, state that they had observed a luminous opening in the edge of the moon, about forty seconds before the end of the eclipse, and they assign to it an extent of 156 leagues. A similar observation was made, by Admiral Ulloa, in 1778. The luminous point which he perceived on the north-west portion of the moon was, according to him, 109 leagues in length, being a narrow opening or perforation of our satellite, admitting a small portion of the sun's light. M. Arago, without absolutely denying the existence of this opening, states that, in the observations at Perpignan, there was nothing to confirm it. During an eclipse, the moon is designed in black, upon the sun, in its true form. The region of the sun which remains visible is, therefore, limited by two portions of circumference. In the points in which they meet, these two arcs, one dark, the other luminous, form two curvilinear lines which are called *horns*, and which are sometimes very thin and sharp. The luminous rays of the sun, which define clearly even the summit of the horns and surrounding parts, cross the surface of the moon to arrive at the earth. This preliminary description introduces some remarks by M. Arago, on the important question as to a lunar atmos-

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phere. If, says this gentleman, the moon had a sensible atmosphere, these rays would deviate, the circular form of the sun would be affected, and the horns would show inflections and irregularities. Nothing of this kind was seen at Perpignan. It was only at rare intervals that the horns appeared mutilated, and they were never so completely. The observations on the bright spots of the sun led the astronomers of Perpignan to the same conclusion as to the non-existence of a lunar atmosphere. When the edge of the moon, during the eclipse, passed a solar spot nearest the black disk of the sun, it had the same luminous intensity as the remainder. This equality of light, says M. Arago, would not have existed if a vapor of any kind, even of no greater extent than the distance of the Luxembourg from the Observatory, had surrounded the moon as an atmosphere. The number of stars seen at Perpignan during the height of the eclipse was only ten, from which we may infer that the darkness was at no time great. The accounts given by the ancient astronomers of the eclipses observed by them are very different. According to them the darkness in some cases was more profound than that of night, and the stars shone with a brightness which filled the inhabitants of the earth with admiration and astonishment. It would appear, however, by the accounts of other astronomers who watched the eclipse of the 8th of July, that a greater number of stars was visible than that seen by M. Arago and his colleagues. This was particularly the case at Montpellier, and also at Milan, although without the central range of the eclipse. The thermometrical observations of M. Arago are less extensive than many persons could have wished. He is brief in his account of the change of temperature experienced during the maximum of the eclipse. He states, indeed, that the two minutes and a quarter of the total occultation of the sun sufficed to cool the atmosphere to such an extent, as to cause an abundant dew to fall upon the trees and plants, which were dripping with wet when the sun again made its appearance; but he has omitted to state with precision the degree to which the mercury fell in the thermometer. M. Lentheric, professor of mathematics at Montpellier, explicitly states, that at the commencement of the eclipse there, the thermometer stood at 18° centigrade (about 75 Fahrenheit). At the moment of its greatest obscurity, it marked only 15½°, but at the end of the eclipse, the mercury rose to 20. M. Lentheric relates a curious fact as to the termination of the phenomenon. The dazzling effect of the sudden return of the light, he says, was such, that he could not, at the moment, distinguish the hands of his chronometer, and therefore was unable to determine the moment with the precision desired. An interesting experiment was made by the Faculty of Sciences of Montpellier, to ascertain the luminous intensity at the different periods of the eclipse. The means employed was the daguerréotype. All the proofs gave a sufficiently defined image of the phenomenon to enable the members of the faculty to determine, by actual admeasurement, the relative apparent diameters of the sun and moon. At Toulouse, M. Flangerques not only noted down a fall in the temperature of 4° centigrade during the eclipse, but also saw the mercury fall in the

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barometer. The mercury fell to thirty-one hundredths of millimetres below the height at which it would have stood if the difference of temperature had been the cause of the variation. This depression is, indeed, of itself unimportant, but it nevertheless shows a deviation from the normal action of the barometer, for it is known that this instrument usually goes on rising from the getting up of the sun until nine in the morning when it attains its maximum. M. Arago, in the course of his communication as to the observations at Perpignan, states, that during the latter period of the eclipse, he saw, on the edge of the black disk of the moon, a sort of protuberance of fire, two minutes in height, and presenting an appearance like that of the glaciers of the Alps illuminated by the setting sun. At Narbonne, the appearance was that of a distant light-house. M. Littrow, of Vienna, also noticed this protuberance, and gives to it an extent of five minutes, or the twelfth part of a degree. M. Bouvard, of Digne, distinguished luminous points proceeding from the edges of the moon, but he attributes them to divergent rays. There will naturally be much speculation as to the character of the protuberance noticed by M. Arago. Some members of the Academy have already thrown out the idea of a mountain of the sun rendered visible in the atmosphere of that body. The theory of Herschel is, that the sun, which is the source of light and heat to us, and which has been regarded as an incandescent body, is in reality dark and inhabitable. M. Arago, whilst he affirms that the protuberance which he observed is not of the moon—no such discovery having ever been made even with the most powerful telescopes—does not admit that it is a mountain of the sun, not that there is any thing repugnant in the laws of science in supposing the existence of a mountain of the sun, 17,000 leagues in height—or, according to M. Littrow's calculation of the extent of the protuberance, 50,000—for objects are only large or small comparatively, and Herschel has shown that the sun, by its prodigious mass, might have mountains, even 120,000 leagues in height; but M. Arago's doubts are founded on the diversity of opinions as to the character of this protuberance. This mountain, if it were one, would have presented a fixed projection and the same angle to each of the observers, which was not the case. M. Arago, therefore, is disposed to regard the phenomenon as one of diffraction. It is proposed, however, to determine this point by experiments with artificial means on the summit of some high mountain. Another curious circumstance mentioned by M. Arago, is the following:—At about the middle of the eclipse, M. Arago was able to perceive the whole disc of the moon. What was the light which enabled him to do this? It could not be the ash-colored light (*la lumière cendrée*) left by the eclipse, for that is exceedingly feeble. There is, in this fact, a mystery which is perhaps impenetrable in the present state of astronomical science. The effect of the eclipse upon the population of Perpignan, who were watching it, is described by M. Arago as singular and even affecting. The gravest persons were unable to restrain expressions of joy when the sun re-appeared, and, whilst the eclipse lasted, anxiety was depicted on every countenance. At the foot of

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the citadel in which the astronomers were making their observations, was a regiment of soldiers. They were laughing and full of gaiety until the face of the sun was obscured, when suddenly they seemed struck with dismay and stupor. The effect upon animals was so remarkable, that, if some portion of what is related did not rest on such good authority, it would not be credited. One of the friends of M. Arago had placed five healthy linnets in a cage. During the sudden darkness of the eclipse, three of the five died. The oxen formed into a circle, with their horns thrust forward, as if preparing for the attack of an enemy. At Montpellier, bats and owls left their retreats, and sheep laid down as for the night, and the horses in the fields were in a state of terror. In addition to these facts, it was stated to M. Arago, in the Academy, on the authority of M. Fraisse, a distinguished naturalist, that a swarm of ants in full march stopped short at the moment of occultation. Lond. Athenæum.

Antarctic Expedition.

The *Guernsey Star* has published the following extract, from a letter dated in May last, from the Falkland Islands:—"Captain Ross and the Antarctic expedition are now here. The *Erebus* and *Terror* came in contact, on endeavoring to escape an iceberg, in the seas of the Southern Pole. The expedition will positively be here for five or six months, to repair the vessels and to make observations. Captain Ross has erected an observatory at the old French fort built by Bougainville. A most interesting series of observations is carrying on. Those upon the pendulum are noted every quarter of an hour. Astronomical observations are also carefully made by the officers. Thermometers are placed both above the ground and under it; mine, with my barometers, are now doing duty with the rest, and have the honor to be registered also. The anemometers, showing the direction and force of the winds, will add much to the valuable information afford by Captain Sullivan, R.N., respecting these islands. Pluviameters are also carefully registered. A tide-gauge is by the jetty, and an excellent magnetic observatory, where the dip, intensity, and variation of the needle are carefully registered by able observers. The officers relieve each other in regular watches on these duties; and I never met with such devotees of science. You would be delighted to see Captain Ross's little hammock swinging close to his darling pendulum, and a large hole in the thin partition, that he may see it at any moment, and Captain Crozier's hammock is close alongside of it. The floor of this room is mother earth, from our want of timber. Captain Ross has been so kind, at my request, as to add to these observations another series, to ascertain the rate of evaporation in these islands; and Hooker, the botanist, is also so good as to draw up a report on the grasses, the prevailing gramina being considered as unknown in Europe. The splendid tussack grass is the gold and glory of these islands. It will, I hope, yet make the fortune of Orkney and Irish landholders of peat bogs. Every animal here feeds upon it with avidity, and fattens in a short time. It may be planted

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and cut like the guinea grass of the West Indies. The blades are about six feet long, and from 200 to 300 shoots spring from one plant. I have proved, by several experiments, that one man can cut 100 bundles in a day, and that a horse will greedily devour five of these in the same time. Indeed, so fond of it are both horses and cows, that they will eat the dry tussack thatch from the roofs of the houses in preference to good grass. About four inches of the root eats like the mountain cabbage. It loves a rank, wet, peat bog, with the sea spray over it. Indeed, when the sea beats with the greatest violence, and the sea spray is carried farthest, then the tussack grass thrives best on the soil it loves. All the smaller islands here, though some of them are as large as Guernsey, are covered with tussack, which is nutritious all the year. The whole of the gentlemen in the expedition are delighted with the Falkland Islands, and express themselves as being more pleased with them than even with New Zealand. Some think them in every way better for colonization, even with the drawback of wanting timber trees. When the observations made during their voyage are published, you will be surprised at their favourable account of the climate. In addition to all these scientific observations, the surveying department is exploring and surveying different harbors, and sites for different objects in a new settlement."

Lond. Athenæum.

Astronomical Clock.

After four years labor, the repairs of the astronomical clock at Strasbourg are completed, and it will be set in motion on the meeting of the Scientific Congress on the 28th. In this curious piece of mechanism the revolution of the sun, the moon, and the planets are marked down with scientific exactness. Seven figures represent the seven days of the week, each appearing in its turn on the day allotted to it. The four ages come forward to strike the quarters, and the skeleton Death strikes the hours. At noon the twelve apostles advance in succession to bend down before the figure of our Saviour, who gives them the benediction. At the same moment a cock claps his wings and crows three times. It is said to be one of the most curious pieces of clock-work in Europe. Lond. Athenæum.

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Meteorological Journal for 1842, *kept at the Lancaster Conservatory of Arts and Sciences, Lancaster, Pa., by* WASH. L. ATLEE, M. D., *Obs.*

		Barometer.			External Thermometer.					Hygrom'r, 2 P.M.			Sky.				Winds.				Clouds.			Rain.
		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point.	Diff. dw pt &tem	Wet bulb.		7 A.M Days	2 P.M Days	9 P.M Days		7 A.M Days	2 P.M Days	9 P.M Days	7 A.M Days	2 P.M Days	9 P.M Days	Rain Gauge. Inches
January.																	N.	1	0	4	0	0	0	
	Att. ther.	34.32	40.97	38.06													N. W.	6	8	6	5	6	1	
																	N. E.	3	2	4	0	0	0	
	Average	29.37	29.40	29.45	30.06	40.22	33.39	27.73	33.78	30.87	10.77	34.48	Ent. clr	9	5	13	S.	1	1	3	0	0	0	
	Maximum	30.02	29.94	29.96	43.00	58.50	52.00	39.00	47.25	53.90	20.60	56.00	Ent.cld	8	10	9	S. W.	11	12	6	2	4	0	
	Minimum	28.95	28.93	28.99	12.00	24.00	17.00	12.00	20.50	3.40	0.00	20.00	Par. clr	14	15	9	S. E.	5	4	6	0	0	0	
	Range	1.07	1.01	.97	31.00	34.50	35.00	27.00	26.75	50.50	20.60	36.00					W.	4	3	2	7	8	2	
																	E.	0	0	0	0	0	0	
Omitted		0	1	0	0	1	0	0	0	2	2	2		0	1	0		0	1	0	8	8	15	0.720
February.																	N.	0	0	1	0	0	0	
	Att. ther.	37.00	43.87	39.87													N. W.	5	7	8	4	6	0	
																	N. E.	7	2	2	0	0	0	
	Average	29.43	29.42	29.45	32.54	43.37	34.85	30.05	36.10	29.50	13.61	36.02	Ent. clr	9	4	17	S.	0	1	2	0	0	0	
	Maximum	29.87	29.79	29.77	59.00	70.00	62.00	59.00	64.50	62.09	41.05	65.00	Ent.cld	7	7	6	S. W.	9	7	4	6	3	0	
	Minimum	29.01	28.64	28.62	12.00	20.50	12.00	11.00	15.75	-13.05	0.00	17.50	Par. clr	12	16	3	S. E.	1	3	7	0	0	0	
	Range	.86	1.15	1.15	47.00	49.50	50.00	48.00	48.75	75.14	41.05	47.50					W.	5	3	2	4	0	0	
																	E.	0	1	0	0	0	0	
Omitted		0	1	2	0	1	2	0	1	4	4	4		0	1	2		1	4	2	5	15	11	2.270
March.																	N.	0	1	2	0	0	1	
	Att. ther.	46.34	54.55	49.52													N. W.	10	12	5	6	12	3	
																	N. E.	4	2	1	0	0	0	
	Average	29.50	29.48	29.50	41.18	54.66	45.32	37.89	46.53	39.40	14.86	47.59	Ent. clr	9	4	12	S.	4	1	0	1	1	0	
	Maximum	29.90	29.90	29.78	60.00	75.00	63.00	65.00	64.25	65.00	34.33	65.00	Ent.cld	15	12	11	S. W.	9	12	5	2	6	0	
	Minimum	29.15	29.00	29.00	24.00	37.00	31.00	22.50	29.75	12.67	0.00	30.00	Par. clr	7	13	8	S. E.	3	1	5	0	0	0	
	Range	.75	.90	0.78	36.00	38.00	32.00	42.50	34.50	52.33	34.33	35.00					W.	1	0	6	3	2	0	
																	E.	0	0	1	0	1	0	
Omitted		0	2	0	0	2	0	0	2	2	2	2		0	2	0		0	2	6	10	6	15	1.760

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		Barometer.			External Thermometer.					Hygrom'r, 2 P.M.			Sky.				Winds.				Clouds.			Rain.
		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point	Diff. dw pt & tem	Wet bulb.		7 A.M.	2 P.M.	9 P.M.		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Rain Gauge. Inches
														Days	Days	Days		Days	Days	Days	Days	Days	Days	
April.																	N.	2	2	2	1	1	0	
	Att. ther.	51.37	68.38	56.87													N. W.	6	2	4	3	8	0	
																	N. E.	5	5	5	2	0	0	
	Average	29.47	29.44	29.44	48.82	62.86	58.83	45.45	53.93	46.51	16.69	53.84	Ent. clr	7	4	10	S.	0	2	0	0	0	0	
	Maxim'm	29.34	29.85	29.75	68.50	86.00	72.00	65.00	70.50	67.48	31.27	72.00	Ent.cld	11	10	15	S. W.	6	4	7	0	2	0	
	Minimum	29.05	29.01	28.97	29.00	45.00	40.00	28.00	37.00	27.51	0.00	39.60	Par. clr	12	15	5	S. E.	4	3	8	1	2	0	
	Range	.79	.84	.78	39.50	41.00	32.00	37.00	33.50	39.97	31.27	33.00					W.	3	9	3	7	3	0	
																	E.	4	2	1	2	3	0	
Omitted		0	1	0	0	1	0	0	1	1	1	1		0	1	0		0	1	0	7	7	20	3.840
May.																	N.	6	0	3	2	2	0	
	Att. ther.	56.19	67.48	61.89													N. W.	6	8	9	8	5	0	
																	N. E.	4	2	3	1	1	0	
	Average	29.46	29.44	29.46	53.05	66.14	55.85	48.82	57.08	51.54	14.79	57.98	Ent. clr	7	3	13	S.	2	2	2	0	1	0	
	Maxim'm	29.76	29.75	29.76	67.00	80.00	65.50	63.50	68.50	70.84	27.73	71.50	Ent.cld	8	8	9	S. W.	11	7	.7	6	4	0	
	Minimum	29.09	29.06	29.10	44.00	45.00	45.00	40.00	44.75	32.76	0.00	45.00	Par. clr	16	17	9	S. E.	0	2	4	0	0	0	
	Range	.67	.69	.66	23.00	35.00	20.50	23.50	23.75	38.08	27.73	26.50					W.	2	5	3	4	7	1	
																	E.	0	1	0	1	0	0	
Omitted		0	3	0	0	3	0	0	3	4	4	4		0	3	0		0	4	0	4	8	17	3.710
June.																	N.	6	1	2	1	1	0	
	Att. ther.	64.90	74.88	68.15													N. W.	3	5	5	0	3	0	
																	N. E.	3	1	5	1	0	0	
	Average	29.52	29.52	29.50	62.40	79.62	64.17	58.05	65.32	60.38	13.28	69.25	Ent. clr	5	5	9	S.	2	5	2	1	1	0	
	Maxim'm	29.87	29.84	29.86	75.50	88.00	79.00	68.50	76.00	74.93	23.41	76.00	Ent.cld	12	6	9	S. W.	6	5	4	7	9	0	
	Minimum	29.26	29.24	29.26	48.50	62.00	52.50	41.00	52.00	40.80	0.00	51.00	Par. clr	13	15	12	S. E.	7	4	8	1	2	0	
	Range	.62	.60	.60	27.00	26.00	26.50	27.50	23.00	34.13	23.41	25.00					W.	3	3	4	13	7	0	
																	E.	0	2	0	0	1	0	
Omitted		0	4	0	0	4	0	0	4	4	4	4		0	4	0		0	4	0	4	4	21	4.670

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Meteorological Journal—Continued.

		Barometer.			External Thermometer.					Hygrom'r, 2 P.M.			Sky.				Winds.				Clouds.			Rain.
		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point	Diff. dw pt &tem	Wet bulb.		7 A.M. Days	2 P.M. Days	9 P.M. Days		7 A.M. Days	2 P.M. Days	9 P.M. Days	7 A.M. Days	2 P.M. Days	9 P.M. Days	Rain Gauge. Inches
July.																	N.	5	1	3	0	1	1	
	Att. ther.	71.58	81.41	74.15													N. W.	2	4	3	8	3	0	
																	N. E.	5	4	3	2	3	0	
	Average	29.60	29.60	29.60	68.23	79.52	69.82	63.90	71.63	65.81	13.69	70.12	Ent. clr	9	2	12	S.	3	5	5	0	0	0	
	Maxim'm	29.83	29.85	29.79	75.50	88.50	77.50	72.00	79.50	74.51	20.92	78.00	Ent.cld	5	5	2	S. W.	10	8	9	5	9	0	
	Minimum	29.28	29.39	29.31	60.00	61.00	59.50	54.00	60.50	56.08	0.00	61.00	Par. clr	16	23	16	S. E.	2	1	5	1	0	0	
	Range	.55	.46	.48	15.50	27.50	18.00	18.00	19.00	18.43	20.92	17.00					W.	1	2	1	7	8	0	
																	E.	2	4	1	0	0	0	
Omitted		1	2	1	1	2	1	0	3	2	2	2		1	2	1		1	2	1	4	6	18	4.105
August.																	N.	3	0	0	0	4	0	
	Att. ther.	68.03	78.81	71.90													N. W.	6	8	4	2	2	0	
																	N. E.	6	5	6	1	2	0	
	Average	29.61	29.60	29.60	64.58	78.07	67.10	63.55	71.17	64.03	13.95	68.72	Ent.clr	7	2	11	S.	3	4	1	1	4	1	
	Maxim'm	29.89	29.88	29.86	71.00	84.00	74.00	71.00	77.00	69.85	21.52	73.00	Ent.cld	9	2	5	S. W.	1	4	2	3	5	2	
	Minimum	29.30	29.30	29.31	54.00	68.00	56.00	50.00	60.50	52.12	0.00	60.00	Par. clr	15	25	15	S. E.	6	5	11	8	5	0	
	Range	.59	.58	.55	17.00	16.00	18.00	21.00	16.50	17.73	21.52	13.00					W.	3	1	8	6	5	2	
																	E.	8	2	4	1	2	0	
Omitted		0	2	0	0	2	0	0	2	2	2	2		0	2	0		0	2	0	7	1	16	3.330
September.																	N.	1	2	1	0	2	0	
	Att. ther.	61.42	73.31	63.95													N. W.	7	11	8	5	9	2	
																	N. E.	7	2	6	1	0	0	
	Average	29.54	29.57	29.57	58.00	72.17	59.45	56.08	64.38	58.05	13.95	63.63	Ent. clr	8	4	11	S.	3	0	2	0	0	0	
	Maxim'm	29.77	29.78	29.76	73.00	89.00	76.00	78.00	80.00	73.16	19.07	76.00	Ent.cld	7	3	4	S. W.	9	4	4	2	3	0	
	Minimum	29.15	29.27	29.25	10 00	54.00	43.00	36.00	46.50	38.66	5.97	47.00	Par. clr	15	20	13	S. E.	0	8	3	1	2	0	
	Range	.62	.51	.51	33.00	35.00	33.00	37.00	33.50	34.50	13.10	29.00					W.	2	5	3	9	7	0	
																	E.	1	0	1	0	0	0	
Omitted		0	3	2	0	3	2	0	3	3	3	3		0	3	2		0	3	2	5	4	17	1.345

		Barometer.			External Thermometer.					Hygrom'r, 2 P.M.			Sky.				Winds.				Clouds.			Rain.
		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point	Diff. dw pt & tem	Wet bulb.		7 A.M. Days	2 P.M. Days	9 P.M. Days		7 A.M. Days	2 P.M. Days	9 P.M. Days	7 A.M. Days	2 P.M. Days	9 P.M. Days	Rain Gauge. Inches
October.																	N.	1	0	2	0	1	0	
	Att. ther.	48.00	61.44	53.35													N. W.	11	14	13	1	5	1	
																	N. E.	2	1	1	0	0	0	
	Average	29.54	29.52	29.54	44.31	59.54	47.60	42.05	50.71	44.29	15,28	51.81	Ent. clr	20	11	22	S.	3	3	4	0	0	0	
	Maxim'm	29.89	29.88	29.83	60.00	70.50	58.50	56.00	61.25	54.99	27.73	60.00	Ent. cld	3	4	4	S. W.	2	4	1	5	5	0	
	Minimum	29.12	29.13	29.23	32.00	51.00	36.00	31.00	41.50	33.70	8.88	43.00	Par. clr	7	12	4	S. E.	4	2	2	0	0	0	
	Range	.77	.75	.60	28.00	19.50	22.50	25.00	19.75	21.29	8.85	17.00					W.	6	1	5	1	3	1	
																	E.	0	2	2	0	0	0	
	Omitted	2	4	1	2	4	1	0	6	4	4	4		1	4	1		2	4	1	4	7	7	2.040
November.																	N.	0	0	1	1	3	0	
	Att. ther.	36.40	44.38	39.32													N. W.	9	13	15	3	6	1	
																	N. E.	4	3	3	0	0	0	
	Average	29.53	29.53	29.51	31.40	42.38	33.83	29.92	36.31	32.87	10.01	38.67	Ent. clr	13	5	16	S.	1	3	1	0	0	0	
	Maxim'm	29.89	29.88	29.85	50.00	60.00	50.00	49.00	48.00	53.50	19 62	54.00	Ent. cld	8	8	6	S. W.	2	1	1	2	6	0	
	Minimum	28.84	28.91	28.98	16.00	24.00	17.50	15.00	20.00	5.38	0.00	21.00	Par. clr	9	16	8	S. E.	3	3	3	0	0	0	
	Range	1.05	.97	.87	34.00	36.00	32.50	34.00	28.00	48.12	19.62	33.00					W.	10	6	6	4	1	4	
																	E.	1	0	0	0	0	0	
	Omitted	0	1	0	0	1	0	0	1	1	1	1		0	1	0		0	1	0	7	9	9	2.774
December.																	N.	1	2	1	2	1	0	
	Att. ther.	33.44	37.97	34.66													N. W.	15	15	16	6	11	4	
																	N. E.	2	6	6	0	0	0	
	Average	29.50	29.46	29.49	28.11	35.23	28,74	25.85	30.54	25.44	9.72	32.21	Ent. clr	6	3	8	S.	2	2	0	0	0	0	
	Maxim'm	29,95	29.94	29.93	38.50	42.00	38.00	36.00	37.75	40.00	20.15	40.00	Ent. cld	11	12	13	S. W.	3	1	2	2	2	0	
	Minimum	28.77	28,90	28.81	11.00	19.50	13.50	11,00	16.75	7.35	0.00	18.50	Par. clr	14	16	10	S. E.	3	1	4	0	0	0	
	Range	1,18	1.04	1.12	27.50	22.50	24.50	25.00	21.00	32.65	20.15	21.50					W.	4	3	1	6	3	1	
																	E.	1	1	1	0	0	0	
	Omitted	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	0	0	9	11	18	2.983

Meteorological Journal—Continued.

		Barometer.			External Thermometer.					Hygrom'r, 2 P.M.			Sky.				Winds.				Clouds.			Rain.
		7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point.	Diff. dw pt &tem	Wet bulb.		7 A.M. Days	2 P.M. Days	9 P.M. Days		7 A.M. Days	2 P.M. Days	9 P.M. Days	7 A.M. Days	2 P.M. Days	9 P.M. Days	Rain Gauge. Inches
		Average of 1842.											**Total of 1842.**											
1842.																	N.	26	9	22	7	16	2	
	Att. ther.	50.74	58.53	54.32													N. W.	86	107	96	44	76	12	
																	N. E.	52	35	45	8	6	0	
	Average	29.51	29.50	29.52	46.89	58.98	49.49	44.11	51.46	45.68	13.88	52.03	Ent. clr	109	52	154	S.	24	29	22	3	7	1	
	Maxim'm	30.02	29.94	29.96	75.50	89.00	79.00	73.00	80.00	74.93	41.05	78.00	Ent. cld	104	87	93	S. W.	79	69	52	42	58	2	
	Minimum	28.77	28.64	28.62	11.00	19.50	12.00	11.00	15.75	-13.50	0.00	17.50	Par. clr	150	202	112	S. E.	38	32	66	7	11	0	
	Range	1.25	1.30	1.34	64.50	69.50	67.00	62.00	62.25	88.43	41.05	60.50					W.	44	41	39	71	54	11	
																	E.	12	15	11	4	7	0	
	Omitted	3	24	6	3	24	6	0	24	29	29	29		2	24	6		4	28	12	74	86	184	33.497
		***Average of Winter Months*, 1841–42.**											***Total of Winter Months*, 1841–42.**											
Winter, 1841–42.																	N.	4	2	9	0	1	1	
	Att. ther.	34.91	41.42	38.25													N. W.	15	23	21	11	18	3	
																	N. E.	13	8	12	0	0	0	
	Average	29.41	29.44	29.44	30.78	40.90	33.99	28.64	34.51	30.52	10.78	35.66	Ent. clr	28	13	37	S.	3	4	8	0	0	0	
	Maxim'm	30.03	30.06	30.07	59.00	70.00	62.00	59.00	64.50	62.09	41.05	65.00	Ent. cld	28	29	28	S. W.	29	24	13	12	10	0	
	Minimum	28.80	28.64	28.62	10.50	20.50	12.00	10.50	15.75	13.05	0.00	17.50	Par. clr	34	45	23	S. E.	9	9	15	1	0	0	
	Range	1.23	1.42	1.45	48.50	49.50	50.00	48.50	48.75	75.14	41.05	47.50					W.	13	12	10	15	14	2	
																	E.	3	2	0	0	1	0	
	Omitted	0	3	2	0	3	2	0	3	7	7	7		0	3	2		1	6	2	23	33	47	6.285
		***Average of Spring Months*, 1842.**											***Total of Spring Months*, 1842.**											
Spring, 1842.																	N.	8	3	7	3	3	1	
	Att. ther.	51.80	61.80	56.09													N. W.	22	22	18	17	25	3	
																	N. E.	13	9	9	3	1	0	
	Average	29.48	29.45	29.47	47.35	61.22	51.67	44.05	52.51	45.82	15.45	58.14	Ent. clr	23	11	35	S.	6	5	2	1	2	0	
	Maxim'm	29.90	29.90	29.78	68.50	86.00	72.00	65.00	70.50	70.84	34.33	72.00	Ent. cld	34	30	35	S. W.	26	23	19	8	12	0	
	Minimum	29.05	29.00	28.97	24.00	37.00	31.00	22.50	29.75	12.67	0.00	30.00	Par. clr	35	45	22	S. E.	7	6	17	1	2	0	
	Range	.85	.90	.81	44.50	49.00	41.00	42.50	40.75	58.17	34.33	42.00					W.	6	14	12	14	11	1	
																	E.	4	3	2	3	4	0	
	Omitted	0	6	0	0	6	0	0	6	7	7	7		0	6	0		0	7	6	21	21	52	9.310

	Average of Summer Months, 1842.											*Total of Summer Months, 1842*											
	BAROMETER.			EXTERNAL THERMOMETER.					HYGROM'R, 2 P.M.			SKY.				WINDS.				CLOUDS.			RAIN.
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Reg'r	Mean	Dew point	Diff. dw pt & tem	Wet bulb.		7 A.M Days	2 P.M Days	9 P.M Days		7 A.M Days	2 P.M Days	9 P.M Days	7 A.M Days	2 P.M Days	9 P.M Days	Rain Gauge. Inches
SUMMER, 1842.																N.	14	2	5	1	6	1	
Att. ther.	68.15	73.37	71.40													N. W.	11	17	12	5	8	0	
																N. E.	14	10	14	4	5	0	
Average	29.58	29.57	29.57	65.07	77.07	67.03	61.83	69.37	63.39	13.64	69.36	Ent. clr	21	9	82	S.	8	14	8	2	5	1	
Maxim'm	29.89	29.88	29.86	75.50	88.50	79.00	72.00	79.50	74.93	23.41	78.00	Ent. cld	26	13	16	S. W.	7	17	15	15	23	2	
Minimum	29.25	29.24	29.26	48.50	61.00	52.50	41.00	52.00	40.80	0.00	51.00	Par. clr	44	62	43	S. E.	15	10	24	5	7	0	
Range	.64	.64	.60	27.00	27.50	26.50	31.00	27.50	34.13	23.41	27.00					W.	7	6	8	26	20	2	
																E.	5	8	5	1	3	0	
Omitted	1	8	1	1	8	1	0	9	8	8	8		1	8	1		1	8	1	15	11	55	12.105
	Average of Autumnal Months, 1842.											*Total of Autumnal Months, 1842.*											
AUTUMN, 1842.																N.	2	2	4	1	6	0	
Att. ther.	48.61	59.68	52.21													N. W.	27	38	36	9	20	4	
																N. E.	13	6	10	1	0	0	
Average	29.54	29.54	29.54	44.57	58.03	46.96	42.68	50.47	44.90	13.08	51.37	Ent. clr	41	20	49	S.	7	6	7	0	0	0	
Maxim'm	29.89	29.88	29.85	73.00	89.00	76.00	73.00	80.00	73.16	27.73	76.00	Ent. cld	18	15	14	S. W.	13	9	6	9	14	0	
Minimum	28.84	28.91	28.98	16.00	24.00	17.50	15.00	20.00	5.38	0.00	21.00	Par. clr	31	48	25	S. E.	7	8	8	1	2	0	
Range	1.05	.97	.87	57.00	65.00	58.50	58.00	60.00	67.78	27.73	55.00					W.	18	12	14	14	11	5	
																E.	2	2	3	0	0	0	
Omitted	2	8	3	2	8	3	0	10	8	8	8		1	8	3		2	8	3	16	20	33	6.159

Practical & Theoretical Mechanics & Chemistry.

On the Comparative Expense of Light derived from different sources, and on the Use of Chlorine as an Indication of the Illuminating Power of Coal Gas. By Andrew Fyfe, M.D., F.R.S.E., F.R.S.S.A., &c.

In a paper published in the Edinburgh Philosophical Journal for 1824, I recommended the condensation of the heavy hydro-carbons by chlorine, as an easy and efficacious method of ascertaining the comparative illuminating power of coal gas, while, at the same time, it had the advantage of enabling us to compare one gas with another, though not brought directly into contrast with it, and thus, by fixing on one as a standard, to state the illuminating power numerically.

With regard to the methods now in use, I mean the specific gravity, the quantity of oxygen necessary for combustion, and the depth of shadow, the last is the only one in which we can place any confidence. As to the specific gravity, if the gas be pure, that is, free from carbonic acid and sulphuretted hydrogen, then, the heavier it is, the more likely is it to be of high illuminating power; but this is not always the case: thus, the specific gravity of olefiant gas and of carbonic oxide is the same, but the latter burns with a feeble blue flame, whereas the former gives forth a brilliant light. Now, suppose coal gas to contain little of the heavy hydro-carbon, and a large proportion of carbonic oxide, then the specific gravity may be such as to induce us to expect the illuminating power to be high, when in fact it is not.

The same remark is applicable to the mode of testing by the quantity of oxygen necessary for complete combustion. A gas with much olefiant will no doubt require much oxygen, this gas taking no less than thrice its own bulk; but let us suppose a variety of gases to have the same proportion of olefiant, or of heavy hydro-carbons, while the proportion of the other inflammable gases varies, which, though they consume oxygen, give out little light during their combustion, and we shall find that the amount of oxygen required gives no indication whatever of the illuminating power.

Thus, suppose the composition to be—

Olefiant, - - - - - - -	13	13	13
Carburetted hydrogen, - - -	83	65	51
Carbonic oxide, - - - - -	4	14	8
Hydrogen, - - - - - -	0	8	28
	100	100	100

the first would require 207, the second 180, the third 159, of oxygen, yet the illuminating power would be nearly the same in all. Supposing the heavy hydro-carbons to vary, and even to become considerable, yet the quantity of oxygen may not be in proportion, owing to

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the hydrogen and carbonic oxide, which require only half of their bulk of that gas for combustion. The mode of ascertaining the illuminating power by the shadow is one in which we may place the utmost reliance, provided we burn the gases with the same kind of burners, and pay particular attention to the circumstances affecting the appearance of the shadow; for it is well known that the color of the shadow varies even from the same gas, when the flames from different burners are contrasted; besides, the reflection of light from surrounding objects will also occasion a difference. Great care is therefore necessary when conducting the trials in this way; and it requires nicely adjusted meters, and a regular pressure, so that the consumption shall not vary during the performance of the experiment.

The other method which I formerly recommended is not liable to these fallacies. In the paper to which I have already alluded, the results of numerous trials are given, in which the illuminating power, as shown by the chlorine test, very nearly agrees with those indicated by the photometric process; and these experiments were performed with every possible attention to the circumstances likely to affect the results, *so far as they were then known*. In a paper subsequently published by Drs. Christison and Turner, the accuracy of the chlorine test was called in question, partly because, when testing the gases by the photometric process, as pointed out by Rumford, due attention was not paid to the different circumstances affecting the combustion, and partly owing to the opinion expressed in the paper by the authors, that other ingredients than olefiant exist in coal gas, which afford light by their combustion, and which are also condensible by chlorine. As to the latter objection, it is of little value, provided we find the results indicated by the chlorine test, to agree with the photometric one. With regard to the latter, it must be admitted that, in some trials, where two gases were compared with each other, due attention was not paid to the height of the flame, and to the other circumstances affecting the combustion, which, at the time that I was engaged in the inquiry, were not known to have an influence on the illuminating power. The influence of these has now been fully investigated, and made known, in the paper by Drs. Christison and Turner, and also in that which I read to the Society in 1840. Since then, I have again had my attention drawn to the subject, and have had many opportunities of putting the chlorine method to the test of experiment; and I must say that I am more and more inclined to put the most implicit confidence in it, not only as a very simple, but, at the same time, a correct, method of ascertaining the comparative illuminating power. I trust the results of the trials will not be devoid of interest.

In fixing the illuminating power of the gases by the shadow, two accurately adjusted meters were used, one for the one gas, the other for the other. Sometimes the gases were contrasted with each other; in which case similar burners, consuming the gas under the same circumstances, were employed; and with the view of securing accuracy in the results, the burners were sometimes changed from one gas to

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another; at other times, the light given by the gas was contrasted with that from candles. The gases subjected to trial were sometimes those with which Edinburgh is at present supplied; sometimes they were prepared by myself, in a small apparatus, with the view of having the illuminating power as varied as I could possibly obtain.

It is well known that the quality of coal gas, even when manufactured from the same kind of coal, depends much on the mode of manufacture; when slowly prepared, and when the same charge of coal is long subjected to heat, a larger quantity of gas is given off than when the time for the charge is shorter; but then the illuminating power is low, owing to the gas which is last evolved having very little of the heavy hydro-carbons; and hence those companies who dispose of their coke to advantage, have, besides the quantity of gas to be got, another object in view, viz., the freeing of the coke from all its gaseous ingredients, otherwise it will not be considered valuable, indeed will not be purchased by those in the custom of using it. It is this which, in addition to the difference in the quality of the coal employed, makes such a difference between the quality of gas prepared in England and Scotland; for, as the coke from English caking coal is more prized than that from parrot coal, which is much used in Scotland, the English companies may generally be considered not only as gas companies, but also as coke companies—indeed, they derive a great deal of their profit from the coke. Hence, in judging of the price of gas, we must take into account its quality; and hence, I conceive, the importance of having an easy method of ascertaining this, and of comparing different gases with each other.

In the first series of experiments, the results of which I am now to give, two gases, manufactured under different circumstances, were compared with the light afforded by a wax candle, kept burning, as nearly as possible, with a uniform flame; the gases being consumed in jet burners with a 5 inch flame. Taking the average of several trials, gas A gave a light as 2.16, compared to that of the wax candle as 1; the condensation by chlorine was 15. Gas B, under similar circumstances, gave a light as 1.98; condensation by chlorine 13, and 15 : 13 : : 2.16 : 1.86; by the shadow it was 1.98.

In another trial with other gases, the light was compared with that afforded by a *tallow* candle, (short six.) Gas C, the light was as 2.81, to that of the candle as 1; condensation by chlorine, 15. Gas D, the light was 2.27, chlorine test 12;

and as 2.81 : 2.27 : : 11 : 8.02,
and as 15 : 13 : : 1 : 8.00,

which is a very close approximation.

Two gases were next contrasted with each other, being consumed with fish-tail burners. By the shadow, the light for equal consumption was 1 to .827, by the chlorine 14 : 12, and as 14 : 12 : : 1 : .857. In another trial with the same burners, but with gases prepared at another time, the average of numerous trials by the photometric process, gave the result as 1 to .945; condensation by chlorine was 12.5 and 11.5, and as 12.5 : 11.5 : : 1 : .92.

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With jets, and with other gases, the results were, by the shadow, 1 to 1.185, and, by chlorine, 11 to 14, and 11 : 14 : : 1 : 1.272. Here the approximation is not so close as in some of the others.

The chlorine test was then tried with a gas, the illuminating power of which was inferior to that of the preceding. The trial by the shadow was made at different distances, to secure accuracy. By the one the result was as 1 to 1.347, by the other to 1.338, average 1 to 1.342. The condensation by chlorine was 10 and 14, which very nearly coincides with the others.

The results above stated very nearly agree with each other. In one trial, however, I found that they did not come so close. By the shadow they were 1 to 1.33, by the chlorine 11 to 17, now as 11 : 17 : : 1 : 1.54.

In this instance the discordance may, I think, be accounted for. It is well known that, when the illuminating power of a gas is high, as when it is prepared by the decomposition of oil, it requires a burner with smaller apertures than those used for common coal gas, otherwise it is not consumed to advantage. Now, in the experiment last recorded, in which the condensation by chlorine amounted to 17, a coal-gas jet was used, by which the gas would not give the same amount of light that it would have given, had a burner with smaller apertures been employed. Hence the illuminating power indicated by the shadow does not come up to what, most likely, it would have been with a differently constructed burner. May not this exception prove the accuracy of the proposed test?

From what has now been said with regard to the test which I have proposed, I think we are warranted in placing implicit confidence in it, as a means of indicating the illuminating power of coal gas; indeed, I have no hesitation in stating, that, when the trial is properly conducted, it leads to results more satisfactory than those given by the shadow; for it has this advantage, that, while it is much more easily conducted, it points out the amount of light that ought to be afforded by one gas as compared with another; whereas, unless all the different circumstances that affect the combustion of the gases are attended to, the results by the shadow will not be correct. One of them, in particular, is the kind of burner—for, when gas is rich in matter condensible by chlorine, and a common coal-gas burner is used, the illuminating power indicated by the shadow will, most probably, be below what it really is, owing to the burner not being adapted for the combustion of that peculiar kind of gas; and hence one of the advantages of the chlorine test.

The process practised in the experiments I have detailed is, with a slight modification, the same as that formerly described. Two tubes, of about half an inch in diameter, and 12 inches long, of the same calibre, and graduated to 100 parts, are employed; into the one, 50 degrees of the gas under investigation are introduced, and afterwards into the other there are put 50 of chlorine; the water of the trough being heated to 50, or thereabouts. The coal gas is then transferred into the chlorine, and the tube instantly covered with a shade, to prevent the action of the light. In the course of five minutes, the con-

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densation is complete. Should only one graduated tube be used, the coal gas must be measured first, and then put into another tube, after which the chlorine is measured, and the *coal gas transferred* into it; for, if otherwise, a part of the chlorine would be absorbed by the water, during its passage through it, and thus lead to variable results. As chlorine is absorbable by water, a slight absorption takes place during the continuance of the experiment. Before proceeding to any trials, it is therefore necessary to ascertain the amount of this, and then to deduct it from the condensation occasioned by the action on the coal gas. In the tube which I have used, I found the absorption to be exactly one degree for every five minutes, and which continues in the same ratio, after the action of the chlorine on the hydro-carbon is over. I have, therefore, always deducted one degree for each five minutes from the total loss, as indicated by the rise of the water in the tube. As, however, the action is over in five minutes, I have seldom continued the trial beyond that time, of course deducting one degree from the loss sustained. As chlorine and the condensible matter act on each other in equal volumes, a condensation of 10, when 50 of each are used, indicates ten per cent. of loss by the coal gas.

Should this method of ascertaining the illuminating power of gases be ultimately found to be correct, another important result may follow its introduction into practice. If we can, by it, fix the illuminating power of one gas compared with that of another gas, the quality of which has been previously determined, and which is consumed with a burner that is known to burn it advantageously, and if the gas which we are subjecting to trial by the shadow test does not show such a high illuminating power as we are led to expect, from the known condensation by chlorine, the probability is, that the burners are not adapted for consuming the gas advantageously, and hence the necessity of altering the apertures, till the power by the shadow is what it ought to be, according to the chlorine test.

There is still another advantage attending the introduction of the chlorine test, in addition to those mentioned; it is the facility of comparing different gases with one another, when they cannot be brought together so as to try them by the shadow. The illuminating power may be considered just as the condensation by chlorine, and thus, then, we may state it *numerically*. Thus, taking a coal gas having only one per cent. of matter condensible by chlorine, its illuminating power may be considered as *unity*, and all others would be as *the per centage of condensation*. Hence, also, the illuminating power of gases may be ascertained, as compared with other sources of light.

It is evident, from what has been said, that, in finding the value of a gas as compared with other sources of light, attention must be paid to the *quality* of the gas; a circumstance which, by many, has been totally disregarded, and hence the very discordant results which have been obtained. In comparing the gas by the shadow given by other lights, we must, in fact, not only attend to the different circumstances affecting the combustion; we must also, at each trial, ascertain the amount of condensation by chlorine; for the quality of a gas manu-

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factured on different days, at the same place, will be found to vary considerably. In the trials I am now to state, made with the view of finding the comparative expense of light, as got from candles, oil, &c., I have uniformly kept this in view; and, by doing so, we are enabled to judge of the expense, not only in this town, but also in other places, provided, of course, we know the illuminating power of the gas by the chlorine test.

The first series of experiments were those with candles, of which ten different kinds were tried. Tallow single wick, tallow double wick, cocoa, palm, composite, margerine, diaphane, composition, spermaceti, wax,—all short sixes.

Tallow.—Very different statements have been given of the illuminating power of coal gas, as compared with that from tallow candles, and which has been accounted for by the difficulty of getting the light from the candle to be uniform; the chief cause of the discordance is, however, more probably, the difference in the quality of the gases manufactured at different places. In conducting my trials, I have paid due attention to the former, trying the candles at different times, so as to have a wick of various lengths. The standard gas light, in all the trials, was a jet burning under a uniform pressure, with a flame of five inches, and consuming exactly one foot per hour.

From numerous trials, I found that the tallow, (single wick, short six,) when compared with the gas, and taking the average of all the trials, was as 1 to 3.75. A short six will be found, when properly snuffed, to last for six hours, or very nearly so; and supposing candles to be 7½ per pound, then the cost of each candle is 5 farthings. Suppose the gas to cost 8s. 4d. per 1000 feet,* then six feet will cost 2½ farthings, or very nearly so; accordingly, for half the expense, 3.75 times the amount of light is obtained; in other words, for the same light, the expense of tallow candles is 7½ times that of gas. The gas I employed in these trials contained, on an average, 12 per cent. of condensible matter. Should the gas contain more or less, then the comparative expense would be greater or less, just according to the quantity. In Edinburgh I have found the chlorine test to indicate from 11 to 14 and 15, very rarely is it up to the latter; of late, I have rarely found it to go beyond 13. Considering the foregoing calculation as applying to the gas now supplied to Edinburgh, and presuming it to contain 12 per cent. of matter condensible by chlorine, then the expense of tallow candles is 7½ times greater, *for the same light*, than that of gas consumed by jet burners.

In England, where the gas is generally manufactured from English caking coal, the illuminating power is inferior to that of gas got from parrot coal, or from a mixture of it and common Scotch coal. Now, suppose the price of the gas the same, and that the condensation by chlorine amounts to 6, then the comparative expense of candles and of gas for the same light would be 3.75 to 1.

Similar trials were made with the other candles mentioned.

* I have taken this as being easy for calculation. It is not far from the price of gas in Edinburgh, and in other towns in the neighborhood of the coal districts.

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Double-wicked tallow, 1s. per pound.—This candle burns for 5½ hours, at a cost of 8 farthings; the light, compared to that of the jet, is as 1 to 2.1, making the expense as 7.1 to 1. This candle has the advantage of not requiring to be snuffed.

Cocoa candle, 11d. per pound, will burn for nine hours, at a cost of 7.3 farthings; the light, compared to the jet, is as 1 to 3.6, or the same as that of the common tallow candle, thus making the expense as 7.3 to 1.

Palm candle, 1s. 2d. per pound, will burn for 6.6 hours, expense 9.3 farthings, light 1 to 3, expense as 10.5 to 1.

Composite, 1s. 1d. per pound, lasts for eight hours, expense 8.6 farthings, light 1 to 3, expense 8 to 1.

Diaphane, (French,) 1s. 8d., will last 6.6 hours, at a cost of 12.3 farthings, light 1 to 3, expense 15.1 to 1.

Margarine, nearly, in every respect, the same as diaphane.

Spermaceti, 2s. 6d. per pound, will burn for eight hours, cost 20 farthings, light 1 to 2.6, expense as 16.2 to 1.

Composition candle the same.

Wax, 2s. 6d., burns nine hours, cost 20 farthings, light as 1 to 2.6; expense, therefore, as 14.4 to 1.

Thus the *tallows*, with the exception of the palm, are nearly of the same comparative expense, light for light; the *composition* is a very little more expensive—the others are more than double the expense.

In the foregoing calculations, I have supposed the gas to be consumed by jets; but I have already shown, in the paper read before the Royal Scottish Society of Arts, and published in its Transactions for 1840, that this is the least profitable method of burning it. For *equal consumpts*, the light given by other burners is much greater; thus, taking the jet as 100, that from a fish-tail is 140, from the bat-wing 160, and from a properly constructed argand 180. Accordingly, by consuming the gas with these, the comparative expense will be still farther reduced. The following table gives the comparative light and expense, according to the kind of burner used.

In conducting the experiments with the view of ascertaining the illuminating power of oil, compared with that of gas, I used argand oil-lamps of the common construction, and also others with contrivances adapted to them, which have lately been recommended for increasing the light. The first trials were made with *sperm* oil, the cost of which, at the time the trials were made, was 9s. 8d. per gallon, that is, 1s. 2½d. per pint. It was burned in a common argand, consuming the oil under the most favorable circumstances. In endeavoring to fix the illuminating power, I contrasted it with an argand gas burner, having forty-two holes, and consuming three feet per hour. I found, however, considerable difficulty in coming to accurate results, partly from the variation in the flame of the oil, partly also from the difference in the appearance of the shadow. Six trials were made at different times, and with the lights at different distances. These varied from 2 to 2.4, taking the oil as 1. The average of the different trials gave 2.35. A pint of oil was found to burn 14 hours, at a cost of 14½d.; the consumpt of gas for the same time (3×14) was 42 feet,

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Candles. Short Sixes.	Burns hours.	Light compared with Jet.	Cost in farthings.		Expense of Candle compared with Jet.	Light comp'd with Fish-tail.		Expense compared with Fish-tail.		Light compared with Argand.		Expense com'd with Argand.		Compt've Expense of candles for equal light.
		Candle 1.	Candle	Gas	Candle. Gas.	Candle	Gas	Candle	Gas	Candle	Gas	Cand.	Gas	
1. Tallow.														
Single wick	6	1 to 3.6	5	2.4	7.5 to 1	1	5.	10.5	1	1	6.48	13.5	1	1.0
2. Tallow.														
Double wick	5.5	1...2.1	8	2.2	7.1 .. 1	1	2.9	9.94	1	1	3.76	12.78	1	1.46
3. Cocoa	9	1...3.6	7.33	3.6	7.33.. 1	1	5.	10.22	1	1	6.18	13.5	1	1.0
4. Palm	6.6	1...3	9.33	2.6	10.5 .. 1	1	4.2	14.70	1	1	5.40	18.90	1	1.32
5. Composite	8	1...3	8.66	3.2	8.12.. 1	1	4.2	11.34	1	1	5.4	13.18	1	1.1
6. Diaphane	6.6	1...3	13.33	2.4	15.1 .. 1	1	4.2	21.14	1	1	5.4	14.18	1	2.08
7. Margerine	6	1...3	13.33	2.4	15.6 .. 1	1	4.2	22.68	1	1	5.4	27.5	1	2.15
8. Spermaceti	8	1...2.6	20	3.2	16.2 .. 1	1	3.64	22.7	1	1	4.86	28.44	1	2.16
9. Composition	8	1...2.6	20	3.2	16.2 .. 1	1	3.64	22.7	1	1	4.86	29.2	1	2.16
10. Wax	9	1...2.6	20	3.6	14.4 .. 1	1	3.64	20.16	1	1	4.86	25.92	1	1.96

In the above calculations, no allowance is made for outlay in gas fittings, &c.

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at an expense of 4¼d., but the light was as 2.25 to 1. The comparative expense, therefore, light for light, would be as 14½d. × 2.25 to 4½d.; that is, as 8 to 1, or very nearly so.

Rectified *whale* oil was next tried, the cost of which was 4s. 8d. per gallon. A pint, when consumed under the most favorable circumstances, was found to burn 12 hours, and, contrasted with the gas argand, as before, the light was as 1 to 2.54. The cost of oil was 7d., that of gas for the same time was 3½d., but the light was as 1 to 2.54; the expense was, therefore, for the same light, as 7d. × 2.54 to 3½d.; that is, 5 to 1.

In the preceding trials, the oil was consumed in a common argand, due attention being paid to the different circumstances affecting the consumpt, such as the kind of wick, the height of flame, &c. The next trial was made with the lamp lately introduced under the name of *solar lamp*. In this, a cylinder surrounds that containing the wick, with the upper part bent inwards, so that, the aperture being contracted, the current of air that passes up between the one cylinder and the other, striking against the horizontal part of the outer one, causes a contraction and lengthening of the flame; a longer and narrower glass chimney is at the same time required. The advantages said to attend the use of this construction of burner are, that an oil of inferior quality may be used, while, at the same time, the light is greatly increased.

The solar lamp, containing *solar oil*, with a flame as high as could be got to be steady, and without smoke, was contrasted with the gas argand as before, burning three feet per hour. On comparing the lights, and taking the average of numerous trials, conducted at different distances, and when the wick was in different conditions, they were as 0.98 to 1; so very nearly equal, that we may consider them as so. The oil, per gallon, costs 3s. 8d.; a pint was found to burn eight hours, or very nearly so, at a cost of 5½d. The gas required for the same time is 24, or say 25, feet, which would cost 2½d; accordingly, the expense is rather more than twice, or say twice, that of the gas.

To ascertain whether or not there is any saving by using the apparatus adapted to the solar lamp, the solar oil was consumed with a solar wick, in the same argand with which the trials with the sperm and whale oils were made; and the light, as before, was contrasted with the argand, burning three feet per hour. The light and the consumpt of oil were found to be the same as with the other oils. The cost of the solar oil per pint is 5½d., that of the whale oil 7d.; accordingly, the expense is as the cost of the oils. It has been already stated, that, by using the solar apparatus, the oil gave a light equal to that from an argand consuming three feet per hour, and that the pint of oil will last for eight hours; the expense is, therefore, as 2½d. to 5½d., or say 1d. to 2d. Now, when the solar oil was burned in the common argand, and contrasted with the gas argand, the light was as 1 to 2.54. As the oil lasted for twelve hours, the cost of gas for that time would be 3½d., or very nearly so. The comparative expense was, therefore, as 5½d. × 2.54 to 3½d.; that is, as 3.98 to 1; whereas,

by the solar lamp, it was only as 2 to 1; thus making a saving, by the use of the solar lamp, of nearly one-half of the expense. This peculiar construction of lamp is, therefore, a very great improvement; for not only is there a saving in expense in the outlay for oil, but, for the lighting of large apartments, a smaller number of lamps is required than when common argands are employed.

Naphtha.—This article has been lately recommended as an economical source of light. Though naphtha gives a beautiful and steady light, yet it emits an offensive smell, and, unless cautiously burned, is very liable to smoke, the slightest blast against the flame causing dense black smoke instantly to appear. The appearance of the shadow is so different from that from coal gas, that it is not easy to fix their illuminating power, and consequent comparative expense. In the experiments I have performed, I used the gas argand as before, consuming four feet per hour. The naphtha lamp had a wick of four inches in breadth, and burned with a flame of about half an inch in height. In one trial, I made the illuminating power of the flames, as naphtha 1 to gas 4.33; in another, they were as 1 to 4.239; giving an average of 1 to 4.236. The consumpt of naphtha was a pint in 24 hours, at a cost of 3s. 6d. per gallon; that is, 5¼d. per pint. The gas for the same time would be 24, or say $25 \times 4 = 100$; that is, 10d.; but the light was as 4.236 to 1—therefore the comparative expense comes to be as 2.2 to 1, or very nearly so. Suppose that I have overrated the illuminating power of the gas, as compared with that of the naphtha,—say that, instead of 4.236, it was about 4,—this would reduce the cost of the latter, and thus make the comparative expense as about 2 to 1.

Table showing the Consumption and Expense of Oils, and of Gas, in Argands, burning three feet per hour.

Oils per Pint.	Pint burns hours	Light of gas com'd with oils as 1.	Cost in farthings of		Comparative Expense for equal lights.		Comparative Expense of Oils for equal lights.
			Gas	Oil	Gas	Oil	
Sperm in Argand...........	14	2.35	17	58	1	8	4
Whale do.	12	2.54	14	28	1	5	2.5
Solar do.	12	2.51	14	22	1	3.98	1.99
Solar in Solar lamp.........	8	1	10	22	1	2	1
Naphtha lamp....	24	3.17	40	21	1	2	1

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Table showing the comparative Expense of Light from different sources; Coal Gas, containing 12 per cent. of matter condensible by Chlorine, taken as unity.

Argand Gas,	1.00				
Fish Tail,	1.40	Fish Tail	1.00		
Single Jet,	1.80	"	1.40	Jet,	1.00
Solar Lamp,	2.00	"	1.55	"	1.11
Naphtha,	2.00	"	1.55	"	1.11
Solar oil in com'n Argand,	3.98	"	2.84	"	2.21
Whale oil do.	5.00	"	3.88	"	2.77
Sperm do.	8.00	"	6.22	"	4.41
Tallow candle, (2 wicks,)	12.7	"	10.0	"	7.18
Cocoa candle,	13.1	"	10.2	"	7.33
Tallow do. (1 wick,)	13.5	"	10.5	"	7.50
Composite,	14.5	"	11.3	"	8.12
Palm,	18.9	"	14.7	"	10.5
Wax,	25.9	"	20.1	"	14.4
Diaphane,	27.1	"	21.1	"	15.1
Margarine,	28.4	"	22.6	"	15.6
Spermaceti,	29.2	"	22.7	"	16.2
Composition,	29.2	"	22.7	"	16.2

Lond. Mech. Mag.

The great Explosion at Dover.

Having witnessed the great explosion at Dover, on Thursday the 26th, from the summit of the cliff next adjoining it to the southward, and from the nearest point to which any access was permitted, I would gladly place on record, in your valuable Journal, some features of this magnificent operation, which struck me at the time as extremely remarkable, and which have not, I think, been adequately placed before the public in any account that I have seen. These features are, the singular and almost total absence of all those tumultuous and noisy manifestations of power which might naturally be expected to accompany the explosion of so enormous a quantity (19,000 lb.) of gunpowder, and which formed, I have no doubt, the chief attraction of many who came from great distances to witness it, viz.—noise, smoke, earthquake, and fragments hurled to vast distances through the air.

Of the noise accompanying the immediate explosion, I can only describe it as a low murmur, lasting hardly more than half a second, and so faint, that had a companion at my elbow been speaking in an ordinary tone of voice, I doubt not it would have passed unheeded. Nor was the fall of the cliff (nearly 400 feet in height, and of which no less than 400,000 cubic yards were, within an interval of time hardly exceeding ten seconds, distributed over the beach on an area of eighteen acres, covered to an *average* depth of 14 feet, and in many parts from 30 to 50,) accompanied with any

considerable noise; certainly with none which attracted my own attention, or that of several others similarly stationed, with whom I afterwards compared notes. A pretty fresh breeze from the south-west might be regarded as influential in wafting it away, were it not that the fall took place under the lee of the cliff on whose edge we were stationed.

The entire absence of *smoke* was another and not less remarkable feature of the phenomenon. Much *dust*, indeed, curled out *at the borders* of the vast rolling and undulating mass, which spread itself like a simi-fluid body, thinning out in its progress; but this subsided instantly; and of *true smoke* there was absolutely not a vestige. Every part of the surface was immediately and clearly seen—the *prostrate** *flagstaff* (*speedily re-erected in the place of its fall*)—the broken turf which a few seconds before had been quietly growing at the summit of the cliff—and every other detail of that extensive field of ruin, were seen immediately in all their distinctness. Full in the midst of what appeared the highest part of the expanding mass, while yet in rapid motion, my attention was attracted by a tumultuous and somewhat upward-swelling motion of the earth, whence I fully expected to see burst forth a volume of pitchy smoke, and from which my present impression is, that gas, *purified from carbonaceous matter in passing through innumerable fissures of cold and damp material*, was still in progress of escape; but whether so or not, the remark made at the moment is sufficient to prove the absence of any impediment to distinct vision.

As regards the amount of tremor perceived, I must confess having speculated with some little anxiety on the probable stability of the abrupt and precipitous ridge on which I stood; and might therefore have somewhat underrated the exceedingly trifling movement which actually reached that point, and which I think I have felt surpassed by a heavy wagon passing along a paved street. The impression, slight as it was, was single and brief, and must have originated with the first shock of the powder, and not from the subsequent and prolonged rush of the ruins, which I can positively say communicated no perceptible tremor whatever.

I have not heard of a single scattered fragment flying out *as a projectile*, in any direction—and altogether the whole phenomenon was totally unlike anything which, according to ordinary ideas, could have been supposed to arise from the action of gunpowder. Strange as it may seem, this contrast between the actual and the expected effects, gave to the whole scene a character rather of sublime composure than of headlong violence, of graceful ease than of struggling effort. How quietly, in short, the gigantic power employed performed its work may be gathered from the fact that the operators themselves who discharged the batteries were not aware that they had taken effect, but thought the whole affair a failure, until reassured by the shout which hailed its success.

The remarkable absence of noise and tremor which characterized

* It has been stated that the flagstaff continued erect, but this (if I can credit the distinct evidence of my own senses) is incorrect.

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this operation is explained by the structure of chalk as a material, and by the rifty state of the cliff as a body. Of all substances, perhaps chalk is the worst adapted for conveying sound, and the best for deadening the vibration propagated through it by a heavy blow. The initial hammerlike impulse of the newly-created gas on the walls of the chambers of the mines (of which it must be recollected there were *three*, simultaneously exploded), was doubtless thus deadened by traversing at least 75 feet of chalk, even in the shortest direction, or line of least resistance—and *this* must have taken place before the mass could have sensibly moved from its seat by the expansive force generated, which, however vast, proved incapable (as indeed it was expressly provided it should be) to communicate to its enormous load any greater velocity than barely sufficient to rift and bulge it outwards, leaving gravity to do the rest. Nothing can place in a more signal light the exactness of calculation which (basing itself on a remarkably simple rule, the result of long practical experience,) could enable the eminent engineer (Mr. Cubitt), by whom the whole arrangements are understood to have been made, so completely to task to its utmost every pound of powder employed, as to exhaust its whole effort in useful work—leaving no superfluous power to be wasted in the production of useless uproar or mischievous dispersion, and thus saving at a blow not less than 7,000£. to the company.

Collingwood, Jan. 31, 1843. J. F. W. Herschel.

Lond. Athenæum.

On the Progress effected in the Process of Gilding by the Electro-Chemical Method. By Professor A. De La Rive.*

I shall unite under this title the account given of the progress of this application of science to the arts since I made it known in April, 1840.

Different artists have been occupied on it at Geneva, particularly M. M. Bergem, father and son, who have presented the Academy of Sciences at Paris, in the spring of 1840, objects gilded, and which after having been submitted to decisive proofs, have been acknowledged as nothing inferior in any respect, either in solidity or brilliancy, to the best gilding produced by the mercurial method. These gentlemen have brought to the process which I have described some perfections which they have not made known. This mode of gilding appears to meet with some obstacles in its application to pieces of brass for the movements of clocks and watches, because the color which it gives them is not such as is usually given to this species of work.

M. Droin, of Geneva, a distinguished workman, who is employed with M. M. Baute & Co., has succeeded, by following to the letter the process which I have described, in producing beautiful specimens of gilding; but he has remarked, that in order to succeed it is necessary to have the metal that we want to gild (silver or brass) perfectly homogeneous, a quality which it is difficult at all times to meet with.

* Archieves De L'Electricitie, No. 1.

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The gilding will not be perfectly uniform except under this condition.

M. Perrot, of Rouen, has sent to the Academy of Sciences of Paris many samples of different metals which he has gilded by voltaic currents, and which appear to have succeeded very well.

M. Arago likewise presented the Academy of Sciences, in its session of the 5th of May last, with the spring of a chronometer from the Manufactory of Dent, gilded to great perfection by means of the galvanic process. He called to mind, on this occasion, that he had presented to the Academy a multitude of objects in metal, gilded by means of the same process by M. Perrot. M. Perrot had already at this time, also, springs to exhibit, which were gilded in the same manner, and if they were not comprised in the number of objects which he sent, it was because he was awaiting the completion of an experiment in which he had undertaken to gild, at the same time, all the movements of a watch; to gild them not only whilst in their place, but whilst performing their usual functions.

In Germany, a distinguished artist of Stuttgard, Mr. Reinecker, who is the author of a very remarkable process of waving or watering, has brought the process of gilding by the galvanic method to that point of perfection which, under the relation of solidity, leaves nothing to be desired. As to its beauty, it leaves far in the rear every other species of gilding. "If we consider," adds the *Gazette* of Stuttgard (from whence we draw these details), "that in the process of gilding by galvanism there is no disengagement of those mercurial vapors so hurtful to the operator, that the quantity of gold employed is much less than in the ordinary gilding, and that the greater part of the technical portion of the work is so simple that it may be executed by children, this discovery in this branch of industry will then appear of such importance that we can but express our ardent desire to see it generally employed."

M. Boettiger, in the *Annalen der Chemie und der Pharmacie* (vol. xxxv., p. 350), describes the efforts which he has made to gild and platinize the plates of copper in relief which have been obtained by the process galvanoplastic.

He tried, at first, to platinize them by the galvanic method, making use of a solution of choride of platina very neuter and very weak. He has succeeded, but he has found that it was necessary to have six immersions in the chloride of platinum to produce a covering of platinum of very small thickness; and again, this covering had not a very good color, but was rather grey than white.

Having found, by succeeding experiments, that for gilding no salt is preferable to the double chloride of gold and sodium, M. B. endeavored to employ, in platinizing, the double chloride of platinum and sodium. The experiments which he has thus made have perfectly succeeded. In most cases he did not find it necessary to give more than three immersions to re-cover with a sufficiently strong layer of platinum the largest surface of copper; the color also appeared of a much purer white. There is one circumstance, however, to which it is always necessary to pay attention in platinizing copper and other

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metals, which is, strongly to rub the object with a small piece of linen, and to scour it immediately with chalk each time, without exception, that it is withdrawn from the solution of platinum. It is worthy of remark also, that whether in silvering, in gilding, or in platinizing, those objects which have the highest polish are those also which receive the metallic layer with the greatest facility and beauty. Mr. Boettiger thinks, that in order to produce good gilding on copper, it is necessary to commence by covering it with a cuticle of platinum, which is easy, and of very little expense; the gilding is far more beautiful and more durable than that obtained by the direct gilding of the copper. It is easy to obtain the double chloride of platinum and sodium by mixing equal parts of dry chloride of platinum and of pure common salt in distilled water. It is very necessary also to rub the metal with fine sand, moistened with hydrochloric acid mixed with chalk, in such a manner as to leave no traces of the oxide of copper, for platinum will not be precipitated on those places where any of it remains, and it will suffice to rub again those places, in order to determine this deposit of platinum, when the plate of copper is again put into the solution as the negative metal of the pair.

I cannot avoid remarking, that I have urgently insisted, in my notice, on the necessity of well cleansing the surface of the copper from verdigris before putting it into the solution of gold, and on the importance of successive immersions, and of the rubbing being repeated after each immersion with a fine linen cloth.

M. Snaer, in a work on electro-metallurgy, of which we shall give an account in our next number, employs for gilding voltaic currents far more powerful than those which I have indicated, and which have been generally used. He is said thus to obtain gilding much more solid, and of any thickness, as great as may be required.

He remarks that the process called the English one, of Elphinstone, does not offer this last advantage. In this process the object to be gilded, which is brass, for example, is put into a solution of double chloride of gold and sodium, raised to a high temperature. The gold is precipitated by the effect of the solution of a part of the metal equivalent to that on which the precipitation takes place. Now, as soon as all the surface is re-covered by a thin cuticle of gold, there is no longer a possibility of any part of this surface being dissolved, and thus the gold is no longer precipitated. It can only form, then, a very superficial gilding, and consequently of short duration; whilst, by the voltaic process there is no limit to the thickness which may be given to the lamina of gold. Another inconvenience of the English process is, that there ensues, by the dissolution of a part of the surface to be gilded, an alteration of that surface, a circumstance which proves prejudicial in many cases, especially when it acts on objects the dimensions of which have been very exactly calculated, and ought not be altered, such as the wheels of chronometers, for example.

M. Hammom, an engraver at Geneva, has found great advantage in the engraving by aquafortis, by substituting for the varnish which is made to cover the plate of copper, a cuticle of gold precipitated by voltaic agency: the tracings of the needle are far more delicate.

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The lamina of gold being permanent, and not being broken or carried off like the coating of varnish; when the aquafortis has operated, we may with great facility correct the engraven plate if it has any defect, which is impossible in the old process. We shall give to our readers, in one of our next numbers, a specimen of this species of engraving, by means of which we have produced a new apparatus which we purpose describing on a future occasion. An. Elec. Mag. & Chem.

On the Purification of Fish Oil. By MM. Girardin *and* Preisser.

Translated for the Journal of the Franklin Institute, from the "Bulletin de la Société d'Encouragement," for July, 1842.

The constantly increasing price of seed oils (huiles de graines) has drawn the attention of speculators to whale oil; and those who first thought of mingling the latter with vegetable oils, for purposes of illumination, have realized large profits. It is now difficult to find the oils of colza, &c., entirely free from fish oil.

In various scientific and technical works, we find processes for the purification of fish oils, which, although simple, are useless, and rather tend to mislead those engaged in their sale, or purification.

Thus, Mr. Davidson, of Edinburgh, purifies oil by treating it with one per cent. of chloride of lime, diluted with water, under violent agitation; and he assures us that the odor is entirely destroyed, but we obtain only a bleached and thick matter, which is clarified by adding 85 grammes of sulphuric acid, diluted with sixteen or twenty times its weight of water. The mixture is stirred, gently boiled, and, after filtering warm, is suffered to cool and repose for several days. MM. Girardin and Preisser repeated this process without any satisfactory result.

The "Journal hebdomadaire des Arts et Metiers" points out several processes for the same purpose. The first consists in mingling 28 grm. pulverized chalk, and 42 grm. slaked lime, with a gallon of the oil, stirring well, and adding 0.236 litre water; after two or three hours of repose, it is mixed again, and this operation repeated for two or three days; 28 grm. of common salt, dissolved in 0.710 litre water, is then added, the mixture stirred at intervals for two days, suffered to settle, and the oil drawn off.

Another process in the cold, applicable to cod oil, consists in putting into 4½ litres of the oil, previously prepared by the preceding process, 28 grm. of chalk; then, after 24 hours, 28 grm. of potassa, dissolved in 113 grm. water; and finally, after several hours, 57 grm. common salt, dissolved in 473 grm. water. After settling a few days, the oil is drawn off.

Neither of these processes is sufficient, as MM. G. and P. have satisfactorily ascertained. The same journal asserts that the oil is obtained so pure by the following process, that it can be employed in woolen manufactures.

Put into 4½ litres (1 gallon) of impure oil, 35 grm. chalk, an equal amount of slaked lime, and 0.473 litres of water; after stirring, and a

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repose of several days, add 0.473 litres water, and 85 grm. potassa; heat the liquid, without bringing it to boiling, and draw it off when the oil has a light amber color; it has now only a pungent, fatty odor: finally, add 0.473 litres water, containing 28 grm. salt, and, after boiling the mixture for half an hour, turn off the oil into a reservoir. This process does not refine the oil.

Many English patents for the same purpose were tested by Messrs. G. and P.

One treats fish oils in the cold by bone black, in small fragments, and filters through animal charcoal, after repeated agitation. Such a process clarifies the oils, and removes a portion of their empyreumatic odor, but does not in the least diminish their essential odor.

Another method, recently published in France, has succeeded no better. It consists in pouring into the oil a solution of bichromate of potassa, mixing thoroughly, then adding a solution of oxalic acid; the action is energetic, but, after repose and drawing off, the oil still retains its characteristic odor.

There is a process among the French patents, which consists in heating the oil merely to simmering with ten parts of water for five or six hours, and, towards the close of heating, adding a milk of one part of water, with one-twelfth of chalk, and one-twelfth of lime. After settling perfectly, it is drawn off and run into reservoirs, through carded wool, or pounded charcoal. This process clarifies the oils, but decolorizes them imperfectly, and does not at all remove their odor.

At Rouen, they refine whale oil by sulphuric acid, as in operating on seed oils; but this method removes neither color nor odor. If, previous to this operation, it be stirred for some hours with chalk, and a current of steam be passed through it, a bleached liquid is obtained, which, by the addition of a suitable quantity of sulphuric acid, deposites plaster on settling. The clear oil, filtered through animal black, has lost a portion of its deep color, and has not a strong odor; but it is not perfectly purified, even after many successive filtrations.

The oxygenation of oils leads to very bad results. Messrs. G. and P. remark, that oils filtered and treated, whether by chlorides, lime, chalk, or animal charcoal, and then left to themselves for thirty or forty days, deposite a bleached organic substance, soluble in water and ether, analogous to margarine, and, while depositing, the oil is more and more decolorized. Fish oil may be obtained, of a quality resembling fine olive oil in appearance, by exposing it to the sun, then to the action of chloride of lime, and filtering several times through animal charcoal. The odor is lessened, but not entirely removed.

A simple exposure to the sun for several months determines an abundant deposite, while the oil is clarified, and sensibly purified.

If whale oil be brought in contact with caustic ley, employed cold, and in small quantities, the decolorization is hastened; the mass separates into two distinct strata—the upper one, decolorized, is very fluid and limpid, but always odorous; the lower, which is very small, is a mixture of the alkaline solution, strongly colored brown, and of all the solid portion of whale oil analogous to margarine. It is not

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necessary to submit the decanted oil to any other process of purification; in this state it is suitable for all manufacturing purposes, excepting on account of its odor, which is always well defined.

It appears from the experiments of Messrs. G. and P. on fish oils, that we at present possess no sufficiently efficacious means of removing their strong and disagreeable odor. The best method, at present, is to submit them either to the action of alkalies, or to the successive action of chalk, steam, and sulphuric acid; to suffer them to repose, and filter several times through animal charcoal. We thus obtain a clear oil, less colored, and of a less repugnant odor; but its want of odor is out of the question.

The refining and purification of fish oils is the more important, since, for the last twelve years, their importation has constantly increased. Thus, in 1827, there was entered only 3,000,000 kilogrammes, (about 6,000,000 lbs.,) the greater part of which came from the islands of St. Pierre and Miquelon; while, in 1839, the importations amounted to 9,200,000 kilogrammes, representing a value of 5,500,000 francs.

On a Gaseous Voltaic Battery. By W. R. Grove, Esq., M. A., F. R. S., *Professor of Experimental Philosophy in the London Institution.*

In the Philosophical Magazine for February, 1839, I have given an account of an experiment in which a galvanometer was permanently deflected, when connected with two strips of platina, covered by tubes containing oxygen and hydrogen. At the conclusion of my notice I say, "I hope, by repeating this experiment in series, to effect decomposition of water by means of its composition." The next paper of mine, published in the same year, contains an account of a battery to which the public has since attached my name, and which led me into a different field of research.

In reading over my papers lately, for a purpose alluded to in my letter of last month, I was struck with the above sentence. My impression was, that I had expressed a hope not very likely to be realized; but, after a few days' consideration, I saw my way more clearly, and determined to try the experiment.

As the chemical, or catalytic, action in the experiment detailed in that paper, could only be supposed to take place, with ordinary platina foil, at the line, or water-mark, where the liquid, gas, and platina met, the chief difficulty was to obtain anything like a notable surface of action. To effect this, my first thought was to surround the platina foil with spongy platina, precipitated in the usual way by muriate of ammonia. This was suggested to me by the known action of spongy platina on mixed gas, which would, by its capillary attraction, expose a considerable surface of metal and liquid to the action of the gases. I still think this would be the best mode of effecting the object; but, as it was very troublesome in manipulation, I determined to try the platina platinized by voltaic deposition from the chloride,

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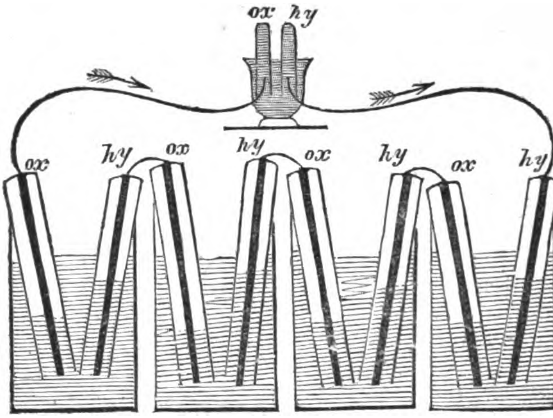

as proposed for a different purpose by Mr. Smee. I therefore caused a series of fifty pairs to be constructed, the form and arrangement of which is given in the annexed figure, where *ox* denotes a tube filled with oxygen; *hy*, one filled with hydrogen; and the dark line in the axis of the tube platinized platina foil, which, in the battery I constructed, was about one-fourth of an inch wide. It is obvious that, by allowing the platina to touch the liquid, the latter would spread over its surface by capillary action, and expose an extended superficies to the gaseous atmosphere. The battery was charged with dilute sulphuric acid, sp. gr. 1.2, and the following effects were produced:

1st. A shock was given which could be felt by five persons joining hands, and which, when taken by a single person, was painful.

2d. The needle of a galvanometer was whirled round, and stood at about 60°; with one person interposed in the circuit, it stood at 40°, and was slightly deflected when two were interposed.

3d. A brilliant spark, visible in broad daylight, was given between charcoal points.

4th. Iodide of potassium, hydrochloric acid, and water acidulated with sulphuric acid, were severally decomposed; the gas from the decomposed water was eliminated in sufficient quantity to be collected and detonated. The gases were evolved in the direction denoted in the figure, *i. e.*, as the chemical theory and experience would indicate, the hydrogen traveling in one direction throughout the circuit, and the oxygen in the reverse. It was found that 26 pairs were the smallest number which would decompose water, but that four pairs would decompose iodide of potassium.

5th. A gold leaf electroscope was notably affected.

6th. The battery was charged with distilled water; the electroscope was affected, and iodide of potassium decomposed.

7th. Although the phenomena were too marked to render it in the least probable that accidental circumstances could have produced the current, still counter experiments were carefully gone through; thus

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the gases were repeatedly changed, oxygen being placed in the tubes which had contained hydrogen, and *vice versa.* The effects were equally powerful, and the direction of the current was reversed.

8th. All the tubes were charged with atmospheric air; no effect was produced.

9th. The battery was charged with carbonic acid and nitrogen in the alternate tubes; not the slightest effect observable.

10th. It was charged with oxygen and nitrogen; not any effect.

11th. With hydrogen and nitrogen, slight effects. The difference between this and the last experiment at first struck me as extraordinary, but, upon consideration, was easily explicable. The liquid, being exposed to the air, would necessarily absorb some oxygen, and this, with hydrogen, would give rise to a current. This was proved by the liquid rising in the hydrogen tubes, but not in those containing nitrogen; and, as a further proof, one set of tubes was charged with hydrogen, and the alternate set with acidulated water without gas; a slight current was perceptible: with oxygen and the liquid in alternate tubes, there were no effects produced.

12th. As the oxygen and hydrogen were procured in the first instance by electrolysis, and as Dr. Schœnbein, in his careful experiments on polarized electrodes, supposed the peculiar substance which he has named Ozone to be a principal agent, I caused the tubes to be charged with oxygen evolved from chlorate of potash and oxide of manganese, and hydrogen from zinc and sulphuric acid; the effects were the same.

The tubes were not all of equal size, nor were they graduated; the exact proportional diminution of gas in each tube could not be ascertained with perfect accuracy; both gases did diminish, and the hydrogen so much more rapidly than the oxygen, that my assistant, who was unacquainted with the rationale of the battery, observed that the hydrogen was absorbed twice as fast as the oxygen. Mr. Gassiot is now preparing a graduated battery of this sort, by which the point will be accurately determined; supposing the gases at the electrodes and the plates exposed to uniform facilities of solution, the quantity evolved should be equal to that absorbed.

Several curious points are suggested by this novel battery.

a. How is its action explicable on the contact theory? I am by no means wedded to any theory, and have constantly endeavored to look with the eye of a contact theorist upon the facts of voltaic electricity, but I cannot see them in that light; if there be any truth in the contact theory, I either misunderstand it, or my mind is unconsciously biased. Where is the contact in this experiment, if not every where? Is it at the points of junction of the liquid, gas, and platina? If so, it is there that the chemical action takes place; and, as contact is always necessary for chemical action, all chemistry may be referred to contact, or, upon the theory of an universal plenum, all natural phenomena may be referred to it. Contact may be necessary, but how can it stand in the relation of a cause, or of a force?

b. Its phenomena present to my mind a resolution of catalysis into voltaic force, in other words, the action of this battery bears the same

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relation to the phenomena of catalysis as that of the ordinary batteries does to those of ordinary chemistry. Whether these effects could be produced by other inoxidable metals, (such as gold or silver,) is an experiment worth trying. The more we examine chemical and voltaic actions, the more closely do we assimilate them. For some mysterious reason, three elements seem necessary for very many, if not for all, chemical actions.

c. This battery is peculiar in having the current generated by gases, and by synthesis of an equal but opposite kind at both anode and cathode; it is, therefore, theoretically, more perfect than any other form, as the batteries at present known act by one affinity at the anode, and have to overcome another at the cathode.

d. This battery establishes that gases, in combining and acquiring a liquid form, evolve sufficient force to decompose a similar liquid, and cause it to acquire a gaseous form. This is, to my mind, the most interesting effect of the battery; it exhibits such a beautiful instance of the correlation of natural forces.

Many other notions crowd upon my mind, but I have occupied sufficient space, and must leave them for the present, hoping that other experimenters will think the subject worth pursuing.

Lond. & Edinb. Philos. Mag.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Facts and Observations on the Explosion of the Boiler of the Steamboat Medora. From a communication made by CHARLES REEDER, *Engineer.*

The Committee on Publications have received some further facts relative to this explosion, from Mr. Reeder, of Baltimore,—the engineer to whom was intrusted the repair of the machinery of the unfortunate Medora, after the fatal disaster which happened to her upon the 14th of April, 1842, and which has already been described in a memoir by B. H. Latrobe, Civil Engineer, inserted in our last November number.

Mr. Reeder cut from the cylinder part of the exploded boiler, several strips of the metal, and subjected them to experiment, with the view of determining the absolute strength of the iron of which that boiler was constructed.

The following tabular statement furnishes the results of these experiments; the sixth trial was upon a strip of No. 3 wrought iron boiler plate, from the manufactory of Brooks & Co., of Pennsylvania; the other five trials were all made upon the iron of the Medora's ruptured boiler.

Since the mean strength of wrought iron boiler plate is about 55,000 lbs. per square inch of section, it is evident from Mr. Reeder's experiments, as recorded in the subjoined table, that the iron of the Medora's boiler must have been *of an inferior quality.*

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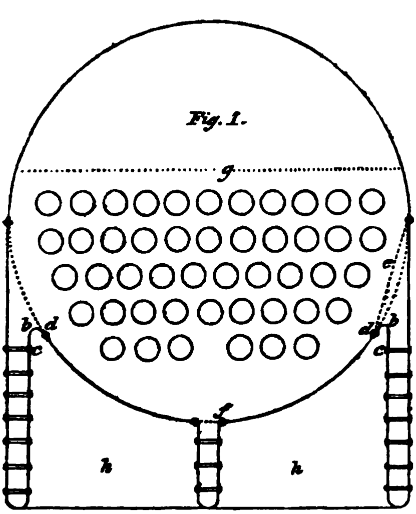
No. of the exper'ts.	Dimensions of the strip tried. Br'dth in inch.	Thick. in inch.	Area of section in sq. inch s.	Direction of strip in the sheet.	Weight which broke the strip in lbs.	Strength in lbs. pr sq. inch of sect'n	Remarks.
1	.250	.237	.05925	across	1720	29029	broke in two minutes.
2	"	"	"	lengthwse	3040	51308	broke instantly.
3	"	"	"	"	2625	44304	do.
4	"	"	"	"	2420	40844	broke in three minutes.
5	"	"	"	"	2440	41181	do.
6	—	—	.06500	"	3780	58154	—



Mr. Reeder has furnished us with two sketches, (Figs. 1 and 2,) which we subjoin, as they exhibit more clearly the internal construction of the exploded boiler of the Medora, than those we have already published.

Fig. 1 is a transverse section of the boiler, in which *g* is the water line, above the return flues, and *h h* the places of the furnaces which heat the water.

Figure 2 is an isometrical sketch, showing the interior of the boiler, and the large openings communicating with the water legs.

Mr. Reeder states that the length of the boiler, between the back and front flue heads, was 198 inches; the apertures, or parts cut away to form the openings of communication with the water legs, 117 inches.

Hence the aggregate breadths of the strips *s*, *s*, Fig. 2, amounted to but 81 inches, measured in the direction of the length of the boiler; but even this breadth of metal was again reduced by the rivet holes, which were $1\frac{3}{4}$ inches from centre to centre, and 46 in number, each being $\frac{11}{16}$ths of an inch in diameter; therefore $198-(117+46\times\frac{11}{16})$, or $198-(117+31\frac{6}{10})=49\frac{4}{10}$ inches, the aggregate breadth of iron left, to resist the internal strain over the side water legs.

The ratio of the iron left, to the whole length of the boiler, is, consequently, $49\frac{4}{10} : 198$, or $1 : 4.08$; so that every 1.02 inches of the length of the boiler would require, from the average of the whole five experiments given above, a force of say 2449 lbs. to rend it asunder, or only about 2400 lbs. per lineal inch of one side.

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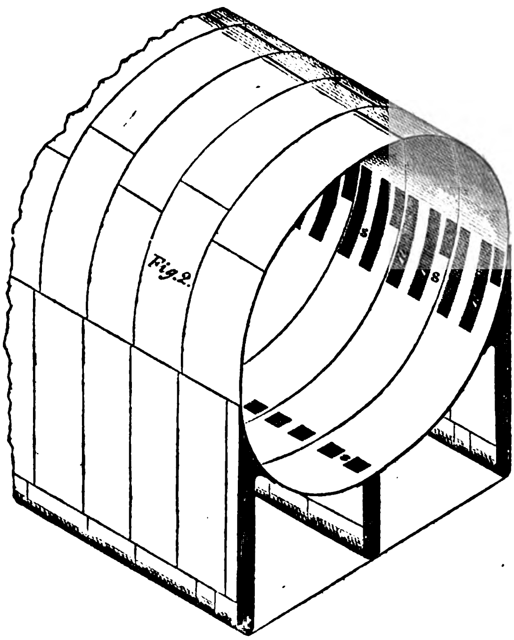
But, taking the mean longitudinal strength of the strips from the boiler, tried by Mr. Reeder, and rejecting the first experiment, we have near 44,000 lbs. per square inch for the average strength of the iron.



Now, if, in the formula $x = \frac{2 P t}{D}$, where x represents the pressure per square inch, we assume, from Mr. Reeder's data,

$$D = 132 \text{ inches;}$$
$$P = 44{,}000 \text{ lbs.;}$$
$$t = .237 \text{ of an inch;}$$

then we have $x = \frac{2 \times 44{,}000 \times .237}{132} = 158$ lbs. per square inch of steam pressure, required to burst the Medora's boiler, if it were a continuous hollow cylinder, and the circumferential strength be alone regarded; but as the metal cut away over the side water legs amounted to $148\frac{6}{10}$ inches, out of 198 inches of the boiler's length, leaving, in fact, but $49\frac{4}{10}$ lineal inches of iron, $\frac{237}{1000}$ of an inch thick, to resist the circumferential pressure within, we have then the following proportion—$198 : 49\frac{4}{10} :: 158 : 39\frac{4}{10}$ lbs.

Therefore, from the data furnished by Mr. Reeder, it seems apparent that the maximum circumferential strain which the boiler of the Medora could have borne without bursting, *did not exceed* $39\frac{4}{10}$ *lbs. per square inch!*

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With regard to the steam pressure which the fully loaded safety valve could fairly impose upon the boiler in question, Mr. Reeder states that the large weight, which our intelligent correspondent, Mr. Latrobe, estimated to weigh 200 lbs., did actually weigh 210 lbs.; and Mr. R. being of opinion that the pressure on a safety valve ought to be calculated only by the steam pressure upon its *lower* surface, he estimates the load of that safety valve thus:—266 lbs. of weights $\times$ 16.128 leverage $=$ 4290.048; to which the weight of the valve, &c., &c., as estimated by Mr. Latrobe, (692 lbs.) being added, we have $\frac{4290.048 + 692}{182.7} = 27\frac{26}{100}$ lbs. pressure of steam per square inch, necessary to raise the safety valve, if perfectly free of adherence to its seat.

Mr. Reeder expresses the opinion that the main defects of the Medora's boiler were, firstly, that too much metal was cut away over the water legs, (*a a*, Fig. 2,) without in any manner bracing the apertures, or substituting the strength so removed; secondly, that the inside sheets of the side legs were joined to the cylinder, (as at *b d*, Fig. 1,) *by being curved downwards*, instead of being continued vertically upwards to a junction; and, lastly, that the flues were so disposed as to prevent the insertion of braces from the top, to support the bottom of the cylinder.

Mr. Reeder further remarks, that the strips *s*, *s*, being 33 inches long, of the same curvature as the cylinder, and subject to be drawn upon both sides, in a straight direction, (*d*, *e*, Fig. 1,) by the steam pressure, formed, in fact, a series of springs, upon which the lower half of the boiler was hung, or supported, so that, when the full steam pressure was on, the several strips would be drawn nearly into right lines, and, when it was off, they would spring back, and recover their curvature—thus allowing the boiler to vary essentially, in its shape, whenever put into use. From the observations which he made, and which he had so good an opportunity of making, Mr. Reeder appears to think that the boiler of the Medora was, in all probability, injured, or weakened, in the two trials which were made with it, prior to the 14th of April; and he expresses the decided opinion, that 23 lbs. pressure per square inch *was enough* to produce, upon the last trial, the fatal explosion which at that date took place; and Mr. Reeder also expresses a belief that this boiler would have *eventually* failed, under a pressure not exceeding 15 lbs. to the square inch.

Mr. R. further observes, that the evidence "of John Watchman, (the builder of the Medora's engine and boiler,) who tried (unsuccessfully) to raise the safety valve, when the steam gauge showed ten inches of steam, might impress some persons with the belief of its being fastened down."

"His mode of raising the valve was by a small cord attached to the end of the lever, and running over a small pulley directly above it, thence to a similar pulley, and finally down to a place convenient to the engineer."

"Under a pressure of 10 lbs. by the gauge, if the weights were out to, or near, the end of the lever, a man would have to overcome a

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weight of about 170 lbs., (in addition to the friction of those pulleys,) by pulling down upon the cord."

"Now, the reason that he could not lift the safety valve, was not because it was fastened down, but simply because, being of less weight himself, he was not able to overcome that which he had to lift."

We will now conclude this subject by remarking, that the mystery which, in the opinion of Mr. Latrobe, seemed to hang over the causes of the explosion of the Medora's boiler, appears to be wholly removed, or cleared up, by the information derived from Mr. Reeder; for, as the steam pressure imposed by the weighted valve amounted, at the least, to 27 lbs. per square inch, whilst the maximum strength of the boiler was only 39 lbs., or but little more than 40 per cent., over the clear circumferential strain, even if we leave the longitudinal stress out of view, there was evidently not sufficient surplus strength to compensate for the imperfections in materials and workmanship, which are inseparable from such constructions, *and which always render a wide margin necessary between the maximum strength and the maximum pressure*—a margin, which a just regard to safety absolutely requires to be such, that the original strength of a steam boiler shall be, at the least, equal to treble the pressure to be ever imposed.

It would therefore seem to be a safe conclusion, that, in seeking for the causes of the explosion of the steamer Medora, *we need not go beyond the insufficient strength and injudicious construction of the boiler, to find a sufficient reason.*

We learn that Mr. Reeder has reconstructed the boiler of this steamboat upon the same general outline, but he has carefully avoided its imperfections; thus, he has placed the flues in regular order above each other, so as to admit of the insertion of stay bars, or braces, both vertically and horizontally; and alongside of the openings into the water legs, which occupy, in the aggregate, much less space than in the old boiler, he has secured broad bars of iron, in such manner as to substitute, or, in effect, to replace, in point of strength, the sectional area of iron removed; finally, he has continued the inner sheets of the side water legs vertically upwards to join the cylinder, and has formed the connecting flanch *internally.*

With these judicious alterations, and the great additional strength thereby imparted to the boiler, the Medora, under the new name of the *Herald*, is now, and for some time has been, working safely and successfully in the Chesapeake Bay.

On the Blowpipe. By Theo. F. Moss, *Mining Engineer.*

The importance of the Blowpipe in analytical research is daily advancing with the progress of chemistry. The knowledge of its use is of the utmost importance to the mineralogist, for with the assistance of a few simple re-agents, he is enabled to determine in a few minutes most of the compounds of a mineral, which by the usual

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process of analytical examination, in the wet way, would require hours and often days. When traveling, he is often compelled to let his curiosity rest satisfied concerning the nature of minerals, which he may find, till he returns to his laboratory; whereas with a knowledge of the use of the blowpipe, he would carry with him the means of determining minerals and their component parts on the spot, and of ascertaining the presence of substances, which if contained in small quantities would be detected only by the most accurate analysis. An examination before the blowpipe is to be considered as preparatory to a quantative analysis by the wet-way.

It is not, however, meant that the blowpipe is infallible in detecting all the compounds of a substance, for one of its components may have such a strong re-action as to conceal the re-action of many others; nor is the following meant as a complete treatise on the blowpipe, but merely to give an insight into its importance, and some of its easier applications, which it is hoped may be of service to the Mineralogist in his summer excursions through our interesting country, and perhaps aid in adding the knowledge of the blowpipe to his other acquirements.

Supposing the reader to be acquainted with the form and manipulations of the blowpipe, I will proceed to describe the order of examination of a substance before the blowpipe and its different re-actions.

The quantity of mineral which serves for examination need be but small; for many operations a splinter the size of a millet seed will suffice, and for some even a much smaller quantity is more than sufficient; another advantage which the blowpipe possesses especially if we have to deal with valuable and rare specimens.

The first operation is to place a small portion of the substance in a thin glass tube closed at one end, then to heat it over a spirit lamp, and afterwards by the blowpipe flame. The object of this operation is to determine what volatile substance the mineral may contain, and sometimes to prepare it for succeeding operations. One of the volatile substances most commonly met with is water, either hygoscopic or chemically combined. The state in which it exists is easily determined by examining the deposite at the cool end of the tube, and ascertaining whether it has an alkaline or acid re-action. An acid re-action of the water results from the decomposition of acid salts, seldom from the decomposition of neutral salts, and then usually from the nitrates, which fill the glass tube with the vapors of nitrous acid, and from the sulphates when sulphurous acid is disengaged, which may be known by the smell.

Fluoric acid is also driven out of some of its compounds when water is present, and this is easily recognised by its pungent smell, and by its destroying the lustre of glass. Besides water, many substances when heated in a glass-tube closed at one end, are volatilized and deposited on the cooler parts of the tube; these sublimates are distinguished from one another by their color, fusibility and volatibility.

A sublimate of red-brown globules, which on cooling become yellow, denote sulphur. A reddish sublimate, or one which in large

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quantities is black, and which on being rubbed has a dark red appearance, shews the presence of selenium. This burns in contact with the air, with a blue flame, spreading a very characteristic smell like decayed horse-radish.

Arsenic sublimes also when the substance contains metallic arsenic or any of the arseniurets, and also some of the arseniates, and is easily known from the vapors, having a smell like garlic.

Quicksilver is easily known, and forms a grey sublimate which on being moved forms into small globules of metallic quicksilver.

Heat sublimes cadmium from most of its compounds, and the sublimate when heated in contact with the air is changed into a yellowish brown vapor of oxide of cadmium.

Tellurium sublimes at a strong red heat, and deposites on the cool end of the glass tube in metallic globules.

The oxide of antimony sublimes in shining needles, melting first into a yellow fluid.

The oxide of tellurium has a similar action, but is not so easily volatilized, and does not sublime in crystals.

Arsenious acid sublimes very easily.

Arsenic acid is changed by a high heat into arsenious acid, and gives the same sublimate.

Osmic acid sublimes in white drops and crystaline needles, and disengages a very characteristic smell which attacks the eyes and nose in a very unpleasant manner.

The chloride of mercury gives a yellow sublimate, which on cooling is greyish white.

After having examined the mineral in a glass tube closed at one end, the next operation is to heat another portion of the substance in a tube open at both ends, the object of which is to see if volatile substances are disengaged by contact with the air; by inclining the tube more or less from a horizontal position, we have it in our power to increase or diminish the access of air. The substances which are thus disengaged, escape either as gases or are sublimed in the cooler end of the glass tube.

Sulphurous acid is one of the substances which escape in this manner as gases. The smallest quantity of this, which may be easily detected, if, when heating, the tube be held nearly horizontal, and then immediately brought in as near a perpendicular position without letting the substance drop out, and held with its upper end to the nose, when the sulphurous acid is easily detected by its pungent smell.

Combinations of selenium, tested in like manner, give a red sublimate of selenium and the peculiar smell of selenium.

Combinations of tellurium give a grey or greyish white sublimate, which melts into clear transparent globules.

Combinations of arsenic give when heated in the glass-tube open at both ends, a similar sublimate to the combinations of arsenious acid, when heated in the tube closed at one end.

The sulphuret of bismuth and the metallic combinations of bismuth give a sublimate of oxide of bismuth, which by heating, melts into

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yellowish brown drops. Minerals containing a small quantity of bismuth give a sublimate which is surrounded by dark yellowish sublimate of bismuth, which becomes paler on heating.

Lead has a similar action, but the sublimate is much lighter.

Sulphuret of lead and selinuret of lead give a white sublimate, which however melts to a grey color.

The sulphuret of tin gives a white flaky sublimate.

Molybdanic acid, a white powdery sublimate and light yellow shining crystals, which are easily volatilized.

(To be continued.)

Making Malleable Iron direct from the Ore.

The President in the chair.—In the conversation which was renewed upon Mr. Pole's paper, 'On the Comparative Friction of Beam and Direct-action Steam Engines,' the author further explained the nature and objects of his paper, which had not been fully understood on the former evening, and illustrated the mode of analytical reasoning, by which he had arrived at his conclusions. He then proceeded to answer the objection which had been raised against the laws of friction adopted by him, and to comment upon the mode of experimenting of Vince and others; showing, on the other hand, by quotations from the recorded experiments of Amonton, Coulomb, Rennie, and Morin, and from the works of Gregory, Brewster, Emerson, Playfair, Barlow, Farey, De Pambour, Posson, Pratt, Whewell, and Moseley, that the views he had taken were correct. He also noticed the variations produced by attrition, and by the introduction of unctuous substances between the rubbing surfaces. These views were corroborated by several members present; some of whom had been quoted as authorities, and the propositions involved appeared to be generally received.

'A new mode of making malleable Iron direct from the ore at one process;' it is the invention of Mr. Clay, and is used at the Shiroa works, near Kirkintilloch. By this process a mixture of dry hæmatite, or other rich iron ore, is ground up fine, with about four-tenths of its weight of small coal; this mixture is allowed to pass gradually through a hopper into an oven adjoining, and forming part of a species of puddling furnace, into which a given quantity is drawn at stated times, when thoroughly and uniformly heated. The charge is then puddled in the usual manner, but with less labor than when working plate iron; and in about an hour and a half the iron is produced in a malleable state, fit for shingling and rolling into bars After another process of filing and rolling again, malleable iron bars are produced of a quality (as was stated by some members present) superior to the cable bolts or best iron usually made by the long and expensive process of calcining the ore, smelting in the blast furnace, and refining the pig-iron, and the saving of fuel is necessarily very great. The iron was stated, also, to be capable of being converted into steel of superior quality, and when worked by Mr. Heath's plan,

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of uniting manganese in the process, cast steel was produced, which possessed the property of welding or uniting to iron; and, in consequence, all the cutlery which was formerly made of shear steel was now made of cast steel. The cast iron produced by the scoriæ, or refuse slag of this process, is of a better quality, in consequence of the absence of phosphoric acid, which is ordinarily present in the limestone, and as a flux in the blast furnace. This discovery may be the means of working the comparatively unopened mines of hæmatite of rich quality existing in Lancashire, Devonshire, and Cornwall, all of which could be brought into use by this means; and if, as asserted, the iron made good steel, England would be rendered independent of Sweden.

The discussion was renewed upon Mr. Clay's process of making malleable iron from hæmatite ore. It was shown that of the twenty-five thousand tons of steel made annually in this country, not more than two thousand five hundred tons were made from the best quality of Swedish iron; the rest was made from inferior charcoal iron from Russia and Germany, or from English iron, which was not well calculated for converting.—*Trans. Inst. Civ. Eng.*

Lond. Athenæum.

Meteorological Observations for January, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	29°	30°	30.05	30.06	W.	Moderate		Clear.	Clear.
	2	25	39	30.00	29.80	E. S.	do		Cloudy.	Lightly cloudy.
	3	26	23	29.75	29.94	W.	Brisk		Clear.	Clear.
	4	10	24	30.20	30.20	W.	Moderate		Cloudy.	Clear.
	5	24	39	30.00	30.00	S.	do		Cloudy.	Cloudy.
	6	30	41	30.00	30.10	E.	do		Cloudy.	Cloudy.
	7	36	48	30.05	30.05	E.	do		Cloudy.	Cloudy.
☾	8	51	59	29.90	29.80	E. S.	Blustering	.29	Cloudy.	Rain.
	9	34	48	30.10	30.10	W. NW.	Moderate		Clear.	Clear.
	10	41	58	30.30	29.95	SE.	do	.60	Fog.	Rain.
	11	39	50	30.30	30.06	N.	do		Clear.	Cloudy.
	12	39	49	29.85	29.85	NW.	do		Cloudy.	Cloudy.
	13	40	43	29.60	29.60	W.	do	.28	Cloudy.	Rain.
	14	36	32	29.70	29.75	W.	Blustering		Par. cloudy.	Clear.
	15	27	36	30.00	30.00	W.	Moderate		Clear.	Clear.
☉	16	32	43	30.30	30.30	W.	do		Clear.	Clear.
	17	27	39	30.46	30.30	E.	do		Clear.	Clear.
	18	29	46	30.30	29.34	NW.	do		Clear.	Clear.
	19	32	51	30.30	30.20	W. SW.	do		Clear.	Hazy.
	20	48	60	30.20	30.20	W.	do		Cloudy.	Par. cloudy.
	21	46	57	30.05	29.76	W.	do		Cloudy.	Par. cloudy.
☽	22	48	56	29.90	29.75	W.	do		Cloudy.	Clear.
	23	34	45	29.75	29.50	W.	do		Clear.	Cloudy.
	24	46	42	29.25	29.25	W.	Blustering		Flying clouds.	Flying clouds.
	25	33	40	29.44	29.44	W.	do		Clear.	Flying clouds.
	26	21	32	29.44	30.00	NW.	Moderate		Clear.	Clear.
	27	25	36	30.05	30.05	SE.	do	.18	Cloudy.	Rain.
	28	34	43	29.75	29.75	W.	Brisk		Drizzle.	Cloudy.
	29	33	36	30.05	30.10	NE.	Moderate		Cloudy.	Clear.
⊗	30	24	37	30.10	30.00	NE. SE.	do		Clear.	Hazy.
	31	46	42	29.50	29.15	SE.	do	.34	Drizzle.	Rain.
		33.73	42.71	29.96	29.88			1.69		

Thermometer.		Barometer.	
Maximum 60 on 20th. Minimum 10 on 4th.	Mean 38.22	Max. 30.46 on 17th. Min. 29.15 on 31st.	Mean 29.92

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

MAY, 1843.

Civil Engineering.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

[CONTINUED FROM PAGE 225.]

Results of Experiments concerning the Friction and Cohesion of Masonry.

57. In the endeavor to elucidate the subject last referred to, we have embodied, in the following tables, the results of the experiments of Rondelet, Boistard, Morin, &c., upon the resistance of various materials to sliding, either when friction acts alone, or when it is replaced by the cohesion of mortars. It is well ascertained by the researches of M. Morin, that the friction of well dressed stones follows the same laws, of proportionality to the pressure, and of independence of the velocity, and of the extent of the surfaces in contact, as those of woods and metals; that it has the least value during the motion, and that this minimum value should be adopted in planning constructions subjected to shocks; that the resistance before the rupture of the equilibrium is actually due, either to friction alone, or to the mere cohesion of the mortar, according to their reciprocal preponderance; that is to say, it is either simply proportional to the pressure, whatever may be the extent of the surfaces in contact—or, again, simply in ratio with this extent, whatever may be the intensity of the pressure. In the experiments of M. Morin, the loads were not, however, carried far enough to permit the assertion that adhesion and co-

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hesion are really independent of the pressure under which the solidification at first took place.

Table of the ratio of the friction to the pressure of various materials, at the moment of starting from a state of rest, and after a certain repose under that pressure.

Nature of Materials.	Ratio of the friction to the pressure
Experiments of M. Morin.	
Soft limestone, well dressed, upon soft limestone,	0.74
Hard limestone, do. upon do.	0.75
Brick, upon do.	0.67
Oak, (across the grain,) upon do.	0.63
Forged iron, upon do.	0.49
Hard limestone, well dressed, upon hard limestone,	0.70
Soft limestone, upon do.	0.75
Brick, upon do.	0.67
Oak, (across the grain,) upon do.	0.64
Forged iron, upon do.	0.42
Soft limestone, upon soft limestone, separated by a coat of fresh mortar, made with fine sand,	0.74
Experiments of others.	
Cut sandstone upon cut sandstone (Rennie),	0.71
Cut sandstone upon cut sandstone, with fresh mortar between, (Rennie,)	0.66
Granite, well dressed, upon granite, (Rennie,)	0.66
do. upon granite, with fresh mortar between, (Rennie,)	0.49
Hard limestone, polished, upon hard limestone, polished, (Rondelet,)	0.58
Hard limestone, cut, upon hard limestone, cut, (Boistard,)	0.78
Wooden box, upon a pavement, (Régnier,)	0.58
A block of stone, upon a bed of dry clay, (Lesbros,)	0.51
do. upon a bed of moist and soft clay,	0.34
do. upon a bed of moist clay, covered with coarse sand,	0.40

58. As to the proper resistance of mortar to sliding, the result of Morin's experiments presents some variations relative to the influence of the extent of the surfaces, and which he explains by observing that the setting of the mortar is as much more rapid and perfect, as this extent is less; but as, upon this point, these results disagree with those of M. Boistard, also given in the following table, it is better, for the present, to suspend all judgment thereupon.

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Table of the resistance of various materials to sliding, arising from the adherence or cohesion of the cementing mortars.

Kind of Stone and Mortar.	Surface in square decimetres.	Length of setting in days.	Mean resistance per sq. decim're.
Experiments of M. Boistard.			kil.
Cut limestone, upon cut limestone, with a mortar of fat lime and fine sand, set in the air,	1 to 2	17	66
	3 to 5	17	94
Same upon same, the mortar set under water,	4.7	487	12
Same upon same, with a mortar of lime and cement, set in the air,	1 to 2	17	32
	3 to 5	17	53
Same upon same, with a mortar of lime and cement, set under water,	4.7	487	110
Experiments of M. Morin.			
Soft limestone upon soft limestone, with a mortar composed of one part hydraulic lime and three of fine sand, set in the air,	1 to 2	83	180
	2 to 3	48	120
	do.	43	101
	4 to 6	48	100
	7 to 8	do.	94
Common bricks, united by same mortar, set in the air,	1.3	48	140
	2.6	do.	100
Soft limestone upon soft limestone, united by plaster,	2	48	220
	8	do.	280
Blue fossil limestone, well dressed, upon same, united by plaster,	2.5	48	110
	4.5	do.	200

59. If we should wish to make use of the numbers furnished by this last table, in calculating the thickness of the vertical wall, which has heretofore been considered by us (26 and 43); that is to say, in solely having regard to the cohesion of the mortar upon the foundation, we should obtain, on the hypothesis of sliding, the following equation:

$$\frac{\gamma x}{H} = \frac{\delta' p}{2}(\sqrt{1+f^2} - \sqrt{u^2+f^2})^2(1+a)^2$$

in which γ represents the force of cohesion for a square metre of surface, δ' a coefficient of stability properly chosen; p, f, a, and u, the same quantities as in number 1.

This equation, which, moreover, is of the fourth degree in x, on account of the expression of u (26), can be resolved and reduced into a table by precisely analogous proceedings to those in number 43; but we do not insist upon this solution, which is rather unusual, since it answers, in all cases of practical application, to neglect the cohesion of the mortar. We shall solely remark, that its value for unity in length of the wall being expressed by $\gamma e = \gamma H x$, while the weight of this

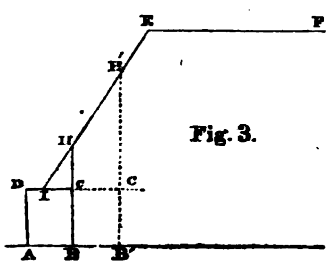

Fig. 3.

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last, in supposing it vertical and covered with a prism of earth, ICH, (fig. 3,) is expressed by $\frac{1}{2}fp\,(x-m)^2\,\mathrm{H}^2+p'\,\mathrm{H}^2\,x$; the cohesion will exceed the friction, when we shall have

$$\gamma\,\mathrm{H}\,x > \tfrac{1}{2}f'fp\,(x-m)^2\,\mathrm{H}^2+f'\,p'\,\mathrm{H}^2\,x,$$

or,

$$x < m + \frac{\gamma - f'\,p'\,\mathrm{H}}{ff'\,p\,\mathrm{H}}\left(1+\sqrt{1+\frac{2ff'\,m\,p\,h}{\gamma - f'\,p'\,\mathrm{H}}}\right)$$

which fixes in advance, independently of the height of the mass of earth BHEF, the limit of the thickness of the revetment within which this circumstance happens, for any designated height H of masonry, and width of berm ($b=m\,\mathrm{H}$). Supposing, for example, $m=0$, or a revetment without a berm, we shall have x, or

$$\frac{e}{\mathrm{H}} < \frac{2\gamma}{ff'\,p\,\mathrm{H}} - \frac{2p'}{fp},\ \text{that is to say,}\ e+\frac{2p'}{fp}\mathrm{H} < \frac{2\gamma}{ff'\,p},$$

in order that the cohesion of the masonry should exceed its friction; so that it is only for low and thin revetments that it will exercise any influence in the case of sliding.

Besides, the consequences would be very different on the hypothesis of rotation, and of a firm and perfect setting of the mortar.

60. We shall now present the result of M. Morin's experiments relative to the friction of stone when in motion; the friction, which should alone be considered in the establishment of constructions subjected to any kind of shocks, or jars.

Character of the Plane Surfaces in contact.	Ratio of friction to pressure.
Soft limestone, well dressed, upon same material,	0.64
Hard limestone, upon soft limestone,	0.67
Common brick, upon do.	0.65
Oak, (across the grain,) upon do.	0.38
Wrought iron, upon do.	0.69
Hard limestone, well dressed, upon hard limestone,	0.38
Soft limestone, well dressed, upon do.	0.65
Common brick, upon do.	0.60
Oak, (across the grain,) upon do.	0.38
Wrought iron, (lengthwise,) upon do. (dry,)	0.24
The same, surfaces being wet,	0.30

Choice of a coefficient of stability relative to sliding on the beds of the courses of masonry.

61. This last table, and that of No. 57, show that the nature of the stones can exercise a great influence on the intensity of the friction; and we should on this ground, therefore, regret that M. Morin did not also make experiments on stones with surfaces merely rough hammered, as well as when perfectly dressed, and, above all, that he should not have examined the influence of a layer of fresh mortar.

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We can, however, judge, from the numbers in the table of article 57, that, in general, this influence would be but slightly sensible for soft stones; whilst, on the contrary, it would be very appreciable for hard stones, which offer by themselves, without mortar, a certain resistance to sliding. But, as in the kind of constructions we are more likely to consider, the beds of the stones are far from being perfectly dressed, and as the mortar, without having attained its final hardness, nevertheless, to a certain degree, is always set, before being subjected to the horizontal action of the pressure; we should, therefore, admit, for the coefficient of friction, a superior value, in some cases, to that expressed by the figures in this last table, and probably we should be on the safe side, and still under the reality, in adopting 0.67, or even 0.70, as a coefficient for calculating the thickness of revetments on the hypothesis under consideration.

62. From this last consideration, if we consider, in particular, (55,) the number 2.65 as a proper value of the ratio $\delta' : f'$, in the case of ordinary earth and masonry, to reproduce approximately the thicknesses furnished by the profile of Vauban for demi-revetments; we shall be led to a coefficient of stability $\delta' = 2.65 \times 0.70 = 1.855$, very little below 1.912, the one which was obtained on the hypothesis of rotation (18). We would arrive at a still smaller value if we took f' below 0.70; which demonstrates that a similar manner of determining the necessary excess of stability for masonry to counteract the effects of sliding, offers much uncertainty, and that perhaps it would be more suitable to fix the value of δ', in each case, from the foreseen chances of injury and destruction to which the revetment might be subjected.

On this account, we think that we shall yield a great deal to stability in adopting, even for military constructions, the value $\delta' = 1.86$, in the case of sliding; and that it will suffice, under many circumstances, particularly where there are very great loads of earth, to take $\delta' = 1.5$, or even 1.4; which, in continuing to consider $f' = 0.7$ as the inferior limit of the coefficient of the friction of masonry, will give, at the most, $\delta' = 2f'$, $q = 1$, (51,) and will, consequently, lead to thicknesses always finite, and which, for great values of the ratio $p' : p$, will, as the calculation shows, constantly remain inferior to those which the hypothesis of rotation furnishes. In effect, in seeking the limit of x, the ratio of the thickness of the wall to its height, on the hypothesis in question, and for the different values attributed to the ratio $p' : p$, and to f, in the table of number 34, we shall, by a comparison of the results with the corresponding numbers of this table, obtain the following for comparison of their relative values:

Rotation,	1.337	1.175	2.144	1.541	1.243	0.927	0.461	0.934	0.789	1.279	0.769
Sliding,	3.193	2.770	2.358	1.524	1.000	0.387	0.333	0.301	0.501	0.458	0.206

63. The difficulty, or rather the uncertainty, which we here experience in fixing the value of the coefficient δ' from the example of the profile of Vanban, chiefly lies in this singular influence of the ratio

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$\delta' : f'$, or of the number q, (47 and 51,) which tends to increase the thickness of revetments in a very rapid manner, and even to render them infinite, when we wish to secure a certain proportional degree of stability, whilst it is quite different in the case of strict equilibrium, or of a feeble stability, for either of which it would even be inferior to that which applies to the hypothesis of rotation.

In truth, the example of infinite loads never presents itself in practice; but, in order to assure a suitable degree of stability against sliding to a sustaining wall, such as ABCD (fig. 3), covered, for example, by a load of earth, IEF, twenty to thirty times its own height, it will be quite repugnant to any constructor to admit that it may be necessary, not only to double, or triple, but to centuple, the thickness which the calculation for the case of strict equilibrium, or $\delta' = 1$, would give, and that, while preserving the same hypotheses relative to the density and friction of earth and masonry. It is, however, the consequence to which they would inevitably arrive in the case under consideration.

To discover the cause of it, *a priori*, it suffices to consider, that, from the nature of the question, the ratio of the pressure of the earth to the weight of the wall and its superincumbent weight of earth, varies very little when the height of the earth is very great, even though there should be a considerable addition, such as BB′ for example, to the thickness of the masonry; and that it tends to converge slowly towards such a small number, that it cannot, in any case, exceed the ratio of δ' to f'; but this ratio of the pressure of the earth to the weight of the wall and its superincumbent load of earth, acquires a much greater value in the case of rotation, on account of the influence of the arm of the lever of pressure.

64. It follows, from this discussion, that, if we intend to maintain $f' = 0.7$ for the coefficient of the friction of masonry, and that, at the same time, we are unwilling to take 1.4, or even a slightly less number, for a coefficient of stability, it would be necessary, in the case of great height in the sustained embankment, to renounce entirely a like application of the calculation, which does not, besides, embrace many of the circumstances favorable to stability, and to seek to attain a proper economy in the masonry, by modifying the form itself of a profile thus become so disadvantageous in this extreme case; for example, by withdrawing, as Vauban often did, the foot of the exterior slope of the embankment, at least as far as the back edge of the top of the wall; a case for which the ratio of the thickness to the height, drawn from the very simple formulas of number 45, will always remain below unity, on the hypothesis under consideration; a value that it would hardly attain, if we took $\delta' = 2.65 f'$, $p' = p$, and $f = 0.6$.

65. This discussion gives rise to the reflection that, in the case of very high embankments, it does by no means follow that the bed of the base of the wall should be that which offers the relative minimum resistance to sliding, when the cohesion of the mortar is entirely neglected; which, in fact, is fully established by the table of number 53, which, as all the formulas of this chapter, remains applicable to

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any horizontal course whatever, of which H indicates the distance below the top of the coping.

Supposing, for example, a demi-revetment without berm four metres high, with a parapet in earth of eight metres in elevation, counting from the coping to the middle of the superior slope, we shall find by this table, which is solely applicable to ordinary earth and masonry, on the hypothesis of $\delta' = 2.65 f'$; 1st, for the base of the wall, as $a = \frac{8}{4} = 2$, the thickness e (8th column) equal to $0.68\ H = 2.72$ metres; 2dly, for the course situated at 0.16 metres below the coping, where $a = \frac{8}{0.16} = 50$, $e = 17.35$, $H = 17.35 \times 0.16 = 2.776$ metres, a value materially greater than the preceding.

The same thing would, *a fortiori*, occur on the hypothesis of $\delta' = 3.3 f'$; but, as is seen, the remark only applies to the courses near the cordon of the wall; it is on the supposition that there is no berm, and that no consideration is taken of the effects of cohesion, which really plays a very important part for these courses.

Finally, the coefficient of stability δ', being at least considered equal (61) to 1.8, we would be led to different results, if we were willing to adopt a less stability, as the eleventh column of the table proves. This discussion shows the danger which there would, in some cases, be in filling earth behind a wall before the mortar had completely set. It, at the same time, explains the cause of the bulging out observed in certain cases, where walls, solidly retained at the ends, nevertheless yield to the action of the pressure of the earth, towards their summit, and about their middle.

66. On considering the result of the discussions and calculations which we have gone through in this chapter, and which appear thorough enough, we are of opinion that there is no cause to apprehend sliding on the beds of any of the courses of masonry, whenever the height of the sustained embankment shall not exceed four times that of the wall, or when, according to common usage, we shall have allowed the mortar in the masonry to have set completely before carrying up the embankment of the superincumbent earth. In the most uncertain cases, it will suffice, on the hypothesis $\delta' = 2.65 f'$, or even $\delta' = 2 f'$, to verify whether the values of m, x, a, &c., which answer to the profile adopted with reference to rotation, render the first member of equation (z) or (y) of number 43, superior to the second, for those courses near the top of the wall.

Besides, the question will be quite changed, as will be seen in Section III, if we take into consideration the sliding of the entire wall on the natural bottom of the foundation. As that which precedes is only applicable to vertical walls, it becomes necessary to show how we can always, by a suitable transformation of profiles, bring under the same head, questions relative to walls with the outer face inclined, or in batter, without recurring to new tables, or formulas.

(To be continued.)

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Railways in Massachusetts. By A. C. MORTON, *Civil Engineer.*

The following tables exhibiting the cost of working, and the receipts, &c. of the principal railways of Massachusetts, for the year 1842, have been carefully compiled for the Journal, trusting they may afford some information of interest to its numerous readers.

They are intended to be a continuation of those published in the number of this Journal for December 1842; the authorship of which was by some mistake, ascribed to Alexander Evans, Civil Engineer.*

At the commencement of the year 1842, one of the most important of these roads (the Western road) was in an unfinished state and had only partially been opened for business. This and several others embraced in the tables have during the last year been extended.

Connexions have been formed with other roads in adjoining states, and large expenditures made with a view of increasing the facilities for doing a more extended business. For this reason the revenue of some of these roads when compared with the cost will not appear as favorable, as when their business relations shall have been fully established and all their improvements completed, which will enable them to do an increased business with greater celerity and economy. The West Stockbridge and Albany road, which is but an extension of the Western road, was not opened throughout the whole line until about the middle of September last; yet at the commencement of last year it was so far completed as, with the use of 15 miles of the Hudson and Berkshire road, to permit the running of the regular daily trains of the Western road over the whole line from the Worcester to the Hudson river, which in connexion with the Worcester road, completed the communication between the cities of Albany and Boston. The Albany and West Stockbridge Rail Road Company, by a special arrangement committed the construction of their road to the Western Rail Road Corporation, and also the sole use of the same, under a lease during the existence of its Charter, or a term of fifty years. The two roads are operated as one entire line between Worcester and Albany, and the business transacted under the name of the Western Rail Road Corporation.

As this great work has but just been completed, and during its progress has much attracted the attention of the public, I here give a brief sketch of its general features, and its first year's operations.

The distance from Worcester to the state line is $117\frac{8}{10}$ miles, thence to the Hudson river $38\frac{22}{100}$ miles, making the total length of road constructed by this company $156\frac{02}{100}$ miles. From Boston by the Worcester road to its intersection with the Western road, is 44.06 miles, making the whole distance from Boston to the Hudson river, $200\frac{08}{100}$, and to the Albany shore, $200\frac{35}{100}$ miles.

There are three summits on this road, viz: Carlton, between the Worcester and Connecticut river, which is elevated 906 feet above

* The tables referred to, were prepared in the early part of the year, but in consequence of being mislaid, were not forwarded for publication until the following autumn.

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the grade of the Worcester road at the Mill Dam basin in Boston. Washington summit between the Connecticut and Hudson rivers, elevated 1456 feet above the same base, and Canaan summit between the state line and Greenbush, which is 954 feet. The depot at Worcester is 476 feet, that at Springfield nearly 71 feet, and that at Greenbush 26 feet, above the same plane of reference. The whole number of planes is 224, of which 40 are level, equalling $9\frac{4}{10}$ miles in extent. Of the greater inclinations of this road there are nearly 3 miles of 60 feet per mile, $1\frac{1}{2}$ miles of 68 and 69 feet, $5\frac{6}{10}$ miles of 74 feet, 6 miles of 78 and 79 feet, and 2 miles of $82\frac{1}{2}$ and 83 feet per mile. There are $75\frac{1}{2}$ miles, or 48 per cent of the whole road, curved to radii, varying from 22,920 to $859\frac{1}{2}$ feet. Of this distance, there are on the Western road, in Massachusetts, 10.6 miles of radii, between 882 and 1910 feet, 13.75 miles between 1910 and 2865 feet, 23 miles between the latter and 5730, and $7\frac{1}{2}$ miles over 5730 feet radius. The most abrupt curvature on this part of the road is encountered at each end of Tuttle Bend bridge, which curves are respectively of 955 and 882 feet radius. On that part of the road in New York, there are 20.46 miles varying from 6000 to $859\frac{1}{2}$ feet radius. The road-bed is graded for a single track, except a portion between Greenbush and the state line, embracing a distance of upwards of 23 miles, which with the deep cuts and high embankments on the whole road, are graded for a double track. The masonry is designed for a double track, with the exception of that for the Connecticut river bridge, and a few small structures. The total length of wooden superstructure of bridges is $1\frac{43}{100}$ miles; those east of Connecticut river are on the plan of Long's patent, and for a double track; all the remaining bridges are built after* Howe's patent, but, with few exceptions, designed for a single track.

There are 15 stone arched bridges, varying in spans from 10 to 60 feet, and in height above the several streams from 12 to 67 feet. At Canaan, near the state line, there is a tunnel of 548 feet in length, 26 feet wide, and 19 feet high. The sides and arch are supported by the rock through which it is cut. It contains 9920 cubic yards, and cost \$35,000, or \$$3\frac{53}{100}$ per cubic yard.

A portion of this road has been very expensive; that part known as the Mountain Division, comprising a distance of about 14 miles, cost \$980,000, or \$70,000 per mile; and a single mile cost \$219,929 The summit section of this division, $1\frac{8}{10}$ miles in length, contained 97,000 cubic yards of rock excavation, and the whole cost \$241,312. The Connecticut river bridge, which is 1264 feet long, being 180 feet from centre to centre of piers, cost, including the casing of the trusses, the ornamental work, and the entire flooring covered with tin, \$131,612. The engineer of the road stated that the cost of this bridge, when first brought into use, was, for foundations, masonry, and superstructure, each, about \$40,000, or, for the whole, \$120,000; since which, the cost of casing, &c., has been added.

The track of this road is formed of longitudinal sills, of 3 by 8

* For a drawing and description of Howe's plan of bridge, as applied on this road to pass the Connecticut river, see vol. iii, 3d series, page 289, of this Journal.

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inches, upon which sleepers of chesnut, 7 feet long and 7 inches through, rest at distances of three feet from centre to centre. The edge rail of the T pattern is used, weighing 56½ lbs. per yard, which is supported by the sleepers. On a portion of the road, the sleepers nearest to the joints of the rails are 2½ feet from centre to centre. The length of turn-out and depot tracks is nearly 14¾ miles, giving a total of track laid by this company of 170¾ miles.

The total cost of the construction of this road, and its full equipment, with an allowance for some further expenditure, is $7,566,791. Relative to the business on this road, the last year, the following extracts from the last report of the directors of this company, will show some of the difficulties they encountered in the first year's operations of the whole line, and their views in relation to its future success:

"At the commencement of the year, the road had but just been partially opened to the Hudson river, giving access to a community before that time secluded from an eastern market, and to a business as yet unknown and untried; and this was accomplished only by the use of fifteen miles of another road, expensive in operation, and unfit for the kind of business important to our success; for the instability of the track of that road, and its high grades, required a great increase of power and of expense upon it. The business sought for had long been accustomed to other, and not undesirable, channels of communication, and to other and larger markets; and it required time and long-continued effort to divert it into a new direction. Everything was comparatively new to us; we had virtually no experience to guide in fixing upon tariffs of charges which would command the traffic; and no standard by which to judge of, much less to estimate with tolerable accuracy, the expenses of transportation, *on such a road.*

"The last year has been, therefore, emphatically, one of experiment—a year for ascertaining the difficulties of the trade in which we were embarked, and for gaining a knowledge of the means by which these might be obviated for the future. Notwithstanding these embarrassments, the undersigned look upon the past year as one of signal success. The *receipts* from the business have exceeded half a million of dollars, equal to more than $42,000 per month, and the expenditures have been but 67 cents per mile run."

The directors conclude their report as follows:

"Under these circumstances, the undersigned look *forward*, also, to the coming year, as one, comparatively, of great promise to the road, in all departments of its business; for they entertain strong hopes that their business will be greatly increased, and with a prospect of diminished expenditure in proportion to its amount."

The cost of transportation of freight on this road, the last year, has been greater than the previous year, which has been caused, partly, by the inequalities of the business in different months, but more particularly by the great preponderance of the trade eastward. The

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amount of freight sent eastward from the Greenbush station, during the last year, was 30,688 tons.

Received at that station, during the same time, from the east,	5,624 "
Difference,	25,064 "

So great has been this excess of business eastward, that it occasionally became necessary to forward whole trains of empty cars from Boston to Greenbush, to meet the demand at that station. This was more particularly the case when the winter produce was seeking a market. The total amount of merchandise transported over this road, the last year, was equal to 6,211,971 tons *net* for one mile, or equal to, carried over the whole road, 156 miles, 39,820 tons. To do this business, the merchandise trains have run 160,089 miles, or equal to 1026 trips over the road, of 156 miles each. This gives 38¾ tons as the average tonnage per trip. Could the freight westward be increased, and more nearly equalized, the average load per trip would approach much nearer the capacity of the engines—consequently, with the same number of miles run, would do a much larger business, at but a small increase of expense. Great efforts have been made to accomplish this desirable object, and, towards the close of the year, with considerable success. The number of through passengers transported over the road was 18,570½, and way passengers, being for any less distance, 171,866, giving a total of 190,436½ during the year. The cost of running, the last year, has exceeded that of the previous year 1.6 cents; but the cost of repairs of cars and engines has been $1\frac{06}{100}$ cents less per mile run.

The total distance run on all the roads embraced in the tables is 1,502,029 miles, and the cost was $1,027,660, being $68\frac{4}{10}$ cents per mile, or 16 cents per mile less than the preceding year.

The cost of running, of repairs of engines and cars, and of road, per mile, is less, it will be seen by reference to table number 1, on the Norwich and Worcester road, than either of the others.

The manner in which this and the Western Railroad Company have exhibited and classified the expenditures for operating their roads the past year, cannot be too highly commended; yet, if these and other companies would extend this classification still further, so as to exhibit the cost of repairs of passenger and freight engines, the amount and cost of fuel for each, the repairs of passenger and freight cars, and all other expenses connected with the transportation of freight and passengers, each under separate heads, they would furnish much useful information to the public. The number of passengers and tons of freight transported should also be given.

The cost of repairs of cars and engines, it will be perceived, varies from 5½ to 20 cents per mile run. The excess in cost of repairs of engines and cars per mile on the Lowell road over others, may in part, perhaps, be attributed to the rigid and unyielding character of the road, it being constructed almost entirely of stone and iron. The average cost for repairs of engines and cars per mile run, for all these roads, is nearly 10 cents, or, exclusive of the highest two, it is $8\frac{41}{100}$

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cents. The aggregate length of these roads (exclusive of the Boston and Maine road, the length of which is not known to the writer,) is 427¾ miles, and the total expenditure for road repairs is $188,820, or an average of $441 per mile. The cost of these repairs on the Boston and Worcester, and Lowell, roads, considerably exceeds that of previous years. The former of these has nearly the whole of the second track finished, or in progress of construction, and the latter has a double track complete.

Table number 2 shows the cost, receipts, expenses, and net income, of these roads. The cost includes all expenses for land, buildings, outfit, &c., or the amount charged to construction up to the close of 1842. The total cost of these roads is $20,976,688.

There has been an increase in the net proceeds of all these roads except three, the aggregate exceeding that of 1841 nearly $254,000. The decrease in the revenue of one of them was in consequence of a ruinous competition with rival lines. The difficulty has been so adjusted as probably to prevent its recurrence. On the other two roads, although the total receipts are considerably above those of 1841, the expenses were increased in a greater proportion, making a small reduction in the net revenue. The aggregate of the expenses of all these roads is 51 per cent. of the total receipts. The expenses are exclusive of interest paid on loans and debts.

Statement of the length, cost of construction, number of miles run, and the cost of repairs, of ten Railroads in Massachusetts, for 1842.—No. 1.

Name of Road.	Length of road.	Maximum grade per mile.	Minimum radius of curvature.	Weight of rail per yard in lbs.	Average cost per mile.	Miles run during 1842.	Cost of running per mile.	Cost of repairs of cars and engines, per mile run.	Cost of repairs of road per mile.
	miles	feet	feet				cts.	cts.	$
Boston and Worcester,	44.50	40	954	60	62,121	241,319	69.08	7.09	1156
Western,	156.14	83	882	56½	48,461	397,295	67.01	9.54	314
Norwich & Worcester,	58.09	20		56	36,647	144,321	51.59	6.66	116
Boston & Lowell	25.75	10	3000	56	76,826	143,607	91.23	20.06	1358
Boston & Providence,	41.17	37.50	5730	55	45,975	132.229	80.78*	10.21	512
Boston & Maine,				56		152,453	52	5.35	
Eastern,	56	40	2865	46½	41,053	184,127	61.25*		264
Nashua and Lowell,	14.25	13.70	900	57	26,666	44,040	99.50	16.25	260
New Bedford & Taunton,	20			59	21,306	40,734	57.33	10.84	172
Taunton Branch,	11			58	22,727	21,904	95.08	11.03	323

* This does not include expenses of ferry.

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Statement of the receipts, expenses, and net income, of ten Railroads in Massachusetts, for 1842.—No. 2.

Name of Road.	Length of road.	Cost of construction.	Receipts for passengers.	Rec'ts for freight, mail, &c.	Total receipts.	Expenses of road.	Net income.	Per centage of income for expenses
Boston & Worcestr	44.50	2,764,396	186,610	162,596	349,206	168,509	180,697	48¼
Western,	156.14	7,566,791	266,447	246,241	512,688	266,619	246,069	52
Norwich & Worcester,	58.09	2,158,561	84,343	53,975	138,318	74,459	63,859	54
Boston & Lowell,	25.75	1,978,286	148,042	130,268	278,310	131,012	147,298	47
Boston & Providence,	41.17	1,892,831	163,788	72,680	236,468	112,824	123,644	47¾
Boston & Maine,		1,260,285	109,681	46,199	155,880	79,278	76,602	51
Eastern,	56	2,299,416	237,023	32,145	269,168	119,039	150,129	44¼
Nashua & Lowell,	14.25	380,000	66,305	64,883	131,188	91,577	39,611	70
New Bedford & Taunton,	20	426,122	43,483	12,292	55,775	23,354	32,421	42
Taunton Branch,	11	250,000	55,711	21,459	77,170	57,777	19,393	74¾

March 15, 1843.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 241.]

LECTURE V.—ON THE COMPARATIVE ADVANTAGES OF DIFFERENT RAILWAYS.

The class will, no doubt, be inclined to think that I have dwelt too long, in the first four lectures of the present course, upon the principles of economy in motive power; but I assure you, that if, in after years, any of you follow up the profession, you will find the subject one of the most vital importance. I shall this evening draw your attention to the different elements of comparison which should guide the engineer in forming a selection from different proposed lines of railway, and shall take, as a text-book for that purpose, Mr. M'Neil's translation of M. Navier's work, *On the Means of comparing the respective Advantages of different Lines of Railway*—a work which I highly recommend for your private study, on account of the clearness and accuracy of the views it contains. M. Navier states "that the elements of comparison of different lines of railway may be divided into two heads; first, the establishment of a very rapid mode of transport—a consideration which should give a preference to the shortest lines, the velocity being supposed to be the same in all; second, the increase of wealth which may result from the establishment of a line of railway. The construction of a railway, like that of a common road, or a canal, is favorable to the advancement of wealth; in the first place, because the actual expense of transport in this di-

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rection is diminished; and, in the second place, because this diminution in the cost of transport increases the value of the neighboring properties, facilitates the establishment of new works, and increases production;" and the saving effected is not merely a private advantage to those individuals who may be directly benefited by it, but is so much actual increase of the wealth of the country at large. "The first of these effects—that is to say, the diminution obtained on the actual cost of transport—is the cause of the second, so that this diminution is the principal circumstance, and that which should be principally considered." Taking it as established, therefore, that diminution in the cost of transport is the principal thing, we come to the result that the cost of motive power, on which this is dependent, is the leading point to be attended to in the formation of any line of railway. Indeed, M. Navier goes so far as to say that this is almost the only circumstance to be attended to; in his own words, "we should even say that the rate of reduction which is obtained upon the actual cost of transport, by the establishment of a new communication, is almost the only circumstance which should be thought of;" but he goes on to say, very justly, "it is also necessary to consider the quantity of goods which is carried, or which may be carried hereafter, in this direction," for the very essence of the railway system is to increase its own traffic; "for it is evident that it may be less advantageous to the country to produce a great economy in the cost of transport upon a line where there is but little to carry, and more advantageous to produce a less economy upon a line where a large quantity of merchandise is carried." These are the principles which I have been endeavoring to impress upon your minds, and which, from their importance, I cannot too often repeat. "It is, therefore," says M. Navier, "generally necessary to take into consideration, in the comparison of different lines, the quantity of traffic which may be established on each, and even the increase in the value of properties, and the development of production to which the establishment of these lines may give rise respectively, according to the nature of the countries which they traverse." I would observe, as a passing remark, that the word *developpement*, in French, generally refers to length; thus the development of a line of railway will be spoken of—meaning the length of that line—whilst, in English, the word refers to an extension of superficies. M. Navier does not go minutely into the examination of these last elements of the question, which rather belong to statistics and political economy than to engineering, but confines himself to the "consideration of the reduction which the establishment of a railway can effect upon the actual cost of transport—a most important consideration—to which, as already remarked, it is always necessary to attend; and this will form, in every case, the principal element of the comparison between different lines, and often leads to determinations purely geometrical or mechanical, and, consequently, exempt from arbitrary deductions."

M. Navier then goes on to state, that "the cost of transport on a railway, as upon a road, or canal, depends on two principal points, which it is necessary to distinguish and consider separately; the first

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of these is the expense of constructing the railway, and the second is the expense of conveying the goods on the railway, when it is constructed. The expense of the construction of the railway is independent of the quantity of merchandise and of passengers that will pass over it. The expense of transport, properly speaking, upon the railway supposed to be constructed, depends, on the contrary, upon the quantity of merchandise or of passengers—that is to say, all other things being equal, the expense will evidently be in proportion to the tonnage." Now, a few years back, the whole time of the House of Commons was taken up with comparing the merits of rival lines of railway, for no sooner was one line proposed than directly a rival line was started. It is well known that, for the Brighton Railway, four different lines were proposed, the discussion on the respective merits of which extended over a considerable length of time. But it is a curious fact, that, in all these discussions, the principle which has been laid down this evening was never once alluded to. Now, in the practical working of railways, the diminution of expense of transport is generally quite independent of the quantity of goods carried; for, after a line is constructed, the charges are generally arranged with reference to rival lines, or to the competition which may exist with the railway; and the interest of the money laid out is scarcely thought of, however much it may have entered into the *a priori* calculations. The Paris and Versailles Railways may be mentioned; two lines were started, one on each side of the river—the government did not like to treat either party harshly, and passed both bills, and both lines are actually executed; and, from the great competition between them, the charges for transport of goods and passengers will probably bear little, or no, relation to the interest of the capital expended. There is, however, another element which renders the calculation of a very complicated nature. The railways are different from common roads, or canals, over which, after they have been once constructed, the public have been left to find their own way—considerations of public safety render it necessary to incur great expenses in terminal and local stations, &c.; and there are also secondary expenses, such as the annual cost of repairs, police, and management, of which it may be said that they depend partly on the interest of the cost of constructing, and partly on the amount of tonnage carried. Now, from experience a general idea can be formed of the expense of these items, but, before going into the details, I will return to M. Navier, who says,—"We may, therefore, admit, without falling into any serious error, that the annual cost of transport on a railway is, in all cases, formed of two parts—the one proportional to the expenses of the construction of the way, and the other proportional to the amount of tonnage carried; and we should also observe, that the cost of transport of one ton of merchandise cannot be specified, unless the number of tons which shall be carried annually from one extremity of the line to the other, be known." Now, hitherto we have been unable to determine *a priori* what these amounts are; but we can tell with great accuracy what they have been on the different lines of railway

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now in operation. The following tables give the average of these expenses on several lines of railway:

Merchandise Traffic.

Heads of charge.	Coal on colliery railways in the north.	Goods on the Liverpool and Manchester Railway.
Locomotive power—wages and repairs,	0.355*	0.425*
" fuel,	0.025	0.125
Total,	0.380	0.550
Wagons,	0.190	0.227
Conducting traffic,	0.075	1.080
Maintaining railway,	0.208	0.307
General expenses,	0.100	0.354
Total cost,	0.953	2.518

* Per ton per mile—in decimals of a penny.

Passenger Traffic.

Heads of charge.	Lond. & Manch'r Railway—average 60 passengers per train.	Dublin & Kingstown Railway—av. 40 passengers per train.
Locomotive power—wages and repairs,	0.170*	0.173*
" fuel,	0.100	0.115
Total,	0.270	0.288
Coaches,	0.054	0.031
Conducting coaching,	0.104	0.113
Maintaining railway,	0.085	0.050
General expenses,	0.091	0.174
Total cost,	0.604	0.656

* Per passenger per mile—in decimals of a penny.

Taking the Liverpool and Manchester Railway as an example, we find the number of passengers to average sixty per train. This may, on the whole, be considered as a fair average on all the railroads throughout the country. Seven years' working of the same railway gives, as the average expense of locomotive power, 0.27*d.*, or about ¼*d.*, per passenger per mile. The gradients do not exceed six or seven feet per mile, with the exception of the inclined plane, and this also is an average amount for most railways—in fact, fuel and wages are so nearly the same on all lines, that the expense of this head can be calculated with great exactness. The expense of locomotive power, also, is the only one which depends upon the gradients. The other expenses, which are independent of the gradients, are—coaching,

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conducting ditto, maintaining way, and general expenses, altogether amounting to 0.33*d.*, which, added to 0.27*d.* = 0.60*d.*, or, in round numbers, three-fifths of a penny per passenger per mile for the expense of transport. Now, let us examine the relative expense of the merchandise traffic. We have, for the expense of locomotive power, 0.55*d.*, or, in round numbers, ½*d.* per ton per mile; for the cost of wagons and secondary expenses, 1.97*d.*, which, added to 0.55*d.*, gives 2.52*d.*, or, in round numbers, 2½*d.* per ton per mile, as the actual cost of transport. Now, let us mark the very striking result of this comparison. Even with all the most recent improvements, and cutting down every expense that can be reduced, the mere transport of passengers costs three-fifths of a penny per passenger per mile, whilst that of goods is only 2½*d.* per ton for the same distance; and of this 1*d.* may be thrown out, arising from other sources, leaving the cost of transport—passengers, three-fifths of a penny per passenger per mile; goods, 1½*d.* per ton per mile. In the first case, we have an amount exceedingly high, in proportion to the present means of transport, whilst the second case presents a result as strikingly low. A ton of goods is equivalent to the weight of fourteen passengers, with 30 lbs. of luggage each.

When the loads to be carried are light, and the velocities at which they are carried considerable, the steepness of the gradients is a matter of comparatively little consequence; but as soon as the engine is loaded to its maximum power, the railway system becomes unable to compete with the canals, so far as relates to the carriage of goods. If these are the results offered to you by past experience, do you not see at once how it affects the question of laying out lines in remote districts, where but a small amount of traffic can be calculated upon? Again, referring to the table, with reference to the difference between carrying slowly and carrying quickly, we find that the expense of locomotive power on the Liverpool and Manchester is 0.55*d.*, or nearly three-fifths of a penny; yet that the expense upon the best railways, where goods are carried at a moderate velocity, is only 0.38*d.*, and the remaining expenses 0.57*d.*, so that it comes to this, that we have —Liverpool and Manchester Railway, 2½*d.* per ton per mile; other railways, with moderate speeds, 1*d.* per ton per mile. M. Navier proposes a case not quite so strong, perhaps, as might be made out, and I will, therefore, refer to the Brighton Railroad for an example, the expense of which, for the 40 miles, has been about £2,600,000, or £60,000 per mile, the interest of which, at 6 per cent., is 10*l.* per mile per day, which is the net receipt, after all expenses are paid, requisite to insure a decent interest to the shareholders. I shall not enter further into the question now; but if those students who are sufficiently advanced will take up the subject, they will soon be able to appreciate my arguments for increasing the limits within which gradients are usually kept—for, supposing the expense of carrying a passenger should be only ⅗*d.* per mile, yet, if you will calculate the additional expense of the interest of £60,000 per mile, you will find ruinous results.

M. Navier having said that the cost of transport is the chief point

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amount of power requisite to draw a given train over a given railway. The elder students will, in connexion with this subject, be aware of the opinion which has been generally entertained amongst engineers, that a rise of twenty feet per mile is equivalent to a mile in length. M. Navier says—"Let us observe that, upon a horizontal line, the power required to draw a given weight is considered as being equal to almost the two-hundredth part of this weight;" but, as I have shown in a previous lecture, the formula for the expression of this power will be $\frac{F}{n}$, taking F as the friction per ton, and n the number of pounds in each ton,—so that what M. Navier calls the two-hundredth part of the weight, will be friction divided by the number of pounds in a ton. Taking the friction at 9 lb., we have $\frac{9}{2240} = \frac{1}{249}$ nearly. At 11 lb., $\frac{11}{2240} = \frac{1}{200}$; and I must here repeat what I have so often before stated to you, that, although experiments have been made which give so low a friction as 4 lb. per ton, that, on an average, M. Navier is nearly right, when we take into consideration the numerous causes of friction. M. Navier considers the power required to draw a given weight "to be independent of the absolute velocity of transit, although there is reason to believe that the tractive power increases with the velocity." Now, it has been said that the friction is the same at all velocities. I cannot fully concur in this opinion. I think the axletree friction may be constant under all velocities; but that, from other causes, there appears to be, I will not call it an increase of friction, but an increase of resistance, the amount of which has not been satisfactorily determined. M. Navier goes on: "We conclude from this, that, in order to transport, with any velocity whatever, constant or variable, a weight, W, to a distance represented by a on a horizontal line, it is necessary to employ the power represented by $\frac{W}{200} \times a$—that is to say, the power necessary to raise the weight to the height $\frac{a}{200}$," or, in other words, to transport a weight any given distance on a horizontal line, is equivalent to raising it the two-hundredth part of that distance in vertical height; and, although this is not quite correct, it is sufficiently so for general purposes. We have before assumed that it is the same thing to go a mile round, as to go over a hill rising twenty feet in a mile. Now, a mile being 1760 yards, or 5280 feet, we have $\frac{W}{200} \times 5280$ as the power required, which is equal to raising the weight 26 feet. But, as the friction varies, I think we have sufficient experience now to say it is about the same thing to rise 30 feet in a mile as to go a mile round; but this is quite independent of the question, whether you should or should not allow on one hand, and deduct on the other, when the slope exceeds

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the angle of repose. I have explained to you, on previous occasions, the difference of opinion that exists on this point. Both Mr. Barlow and M. Navier allow the advantage up to a certain point, which they fix at about 1 in 180, beyond which point they consider the whole advantage gained to be destroyed by the necessity of putting on the brake. Now, in practice, we do not find this to be the case, until we come to 1 in 80, or thereabouts; however, we may take, as a general rule, M. Navier's concluding words on this subject:—"The length of the line remaining the same, the amount of power consumed to effect the transit depends entirely upon the length of the line, and the difference of the level of its extreme points." The practical result which I have endeavored to lay before you this evening is, that the cost of transport is the cost of the power combined with the interest of the original cost of the line, and that the calculation of this combined expense must form the element of comparison between different lines of railway.

(To be continued.)

Facts and Observations on Four and Six Wheel Engines. By John Herapath, Esq.

[Concluded from Page 248.]

London and Brighton Railway.

At Horley station it was intended to have the general engine factory of the company, and a large building has been erected for the purpose. On digging, however, for water, to their surprise, they found it would not do for locomotive purposes. *It literally boils out with the steam, and there is no keeping it in the boiler!* It has been analyzed, but what are its component parts I have not heard. With the ladies, however, who send for it, far and near, for tea, it seems to be a great favorite. The depth of this well is 240 feet, and it is distinguished by an intermittent escape of gas. According to several continuous observations, made by myself and some gentlemen who were there, the bubbling up is like water in rapid ebullition, and occurs very regularly every 70 seconds. This ebullition is preceded for a few seconds by a sort of simmering, which increases rapidly, and ends in the apparent violent ebullition mentioned, and then subsides into a perfect calm. We had no means of collecting and ascertaining what the gas was that escaped. A lighted candle was procured and held down to near the surface of the water by one of the men, but was so badly done as not to be satisfactory. Such as the experiment was, it manifested in the candle no signs of being affected in any way. This water rises to the very top of the tank.

On this line I saw one of the most curious circumstances I have seen upon any line. The Earlswood embankment, which is very lofty, and rests upon a sort of clay base, not long after the opening of the line sank about one-half of it down, from one and a half to two feet below the other half, a field below having risen up to the height of six or seven feet. The down line of rails, therefore, now stands

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state, without any alteration of the lines, or any inconvenience to the traffic. The dip is, of course, not long, with a pretty gradual descent and rise; and the trains, by means of the momentum they acquire in the descent, easily mount the ascent.

On another part of the line, farther down, the engineer, finding he had very troublesome materials to deal with, humored them, and allowed a portion of the embankment to remain about ten feet lower than it was intended to be. At a distance; before one comes to it, this dell has a curious appearance; but the trains travel over it daily without the slightest impediment.

One can hardly estimate the uncertain nature of the materials on this line. At one part, scarcely any effort can keep them up to the mark, and at another, where they have been expected to settle, they remain firm and inflexible. The embankment south of the Ouse Viaduct, for instance, one might reasonably have calculated to settle a trifle, however good the material. At its formation, therefore, the embankment was made a little rounder and higher. But what has been the result? Not one bit has it subsided, and, after twelve months' experience, the round back has been taken off, and the embankment reduced to its proper level.

It has generally been supposed that the line to Brighton runs through a monotonous and uninteresting country; but it is not so. The road to Croydon, both before and after the deep cutting at New Cross, particularly after, is distinguished for its beautiful and picturesque scenery. Beyond Croydon, a country of rather a different character opens upon us, but with most lively and interesting features, and in many places very beautiful. Some parts of the line will equal almost any in the kingdom for its rich and pleasing variety. As a whole, it is a very pleasant line to travel over, though occasionally we are immersed in *deep cuttings* and *tunnels,* which one would rather avoid than court.

The total length of line traveled by this company is better than 56½ miles. They have 31 engines to do the work, of which 30 are in an efficient state to take a train. They are all six-wheel engines, except six of Bury's, which are now about to be converted into six-wheel; and all have, except these six and a coupled engine, outside bearings. One of Bury's has already been made into a six-wheel, of which I shall say more hereafter; but the others, since the unfortunate accident last September, have, in deference to the public, never been allowed to go with passenger trains, but are used for goods, or for ballast, engines. They have one coupled goods engine, which they say works well, and is safe at any speed under thirty miles an hour. All their driving wheels have flanches. The detentions of trains from defective machinery, or derangement of engines, have been about a dozen. They have had no broken cranked axles. Two engines have run off the rails, both four-wheel, and, the superintendent of locomotives says, without any assignable cause.

If I mistake not, one of these runnings off was at the time of the

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accident; and the other, a running off before entering one of the tunnels, about the same time. If so, I have been informed that the first accident occurred from the badness of the road, or from the rails being covered with *debris;* and I believe from one of the same two causes the second happened. Such, at least, is what I have heard from an engineer who was either present the day of the first accident, or the day after; but, if I recollect rightly, on the very day. It is said both happened on a straight road, a thing which on no other line has happened, nor could happen if the road was clear and good. The play of the wheels of the engines with which the accident happened, was half an inch.

The gauge of this line is the same as that of most of the English lines, 4 feet 8½ inch.

It seems they do not know the gross average load of the trains, but the working pressure is 50 lbs. to the inch. The average consumption of coke is 26 lbs. to the mile. They work expansively, and cut off the steam at two-thirds of the stroke, by which they estimate a saving of 6 lbs. per mile.

No motions are said to be observed in their engines but those common to others, and the most motion is described to be in the four-wheel engine. They have no top-heavy engines, but think the motions, such as they are, irrespective of the condition of the road.

The following table, taken from the returns to the government circular in Sir F. Smith's report, contains the *data* of all the engines they then had.

They are all double cranked axle, and all, except six of Bury's, and a goods engine, have outside bearings.

No. of engines.	Diam. of wheels in feet. Front	Driving	Hind	Diam'r of cylinder, inches.	Stroke, inches.	Weight loaded, in tons, &c. Front	Driving	Hind	Total
						tons. cwt.	tons. cwt.	tons. cwt.	tons. cwt.
1	3½	5½	3½	13	18	4 7	5 18¾	2 17	13 2¼
1	5	5coupd	coupled	same	same	4 10	5 10¾	2 9¼	13 10
2*	3½	5½	3½	14	18	5 0	8 0	2 18	15 18
1	same	same	same	12	18	unknown	unknown	unknown	unknown
13	same	same	same	14	18	5 5	8 9	1 5	14 19
6	4	5½	none	same	same	5 13	8 16	none	14 9
1	3½	5	3½	same	same	4 16	8 17	2 5	15 18

* I suspect one, at least, of these engines is wrong, for the numbers I have direct from Messrs. Rennie are different.

These make only 25 engines, but two more had then (November, 1841,) been ordered of Sharp & Co., three of Fairbairn, and one of Rennie, which I understand are since arrived.

My first trip down the Brighton line was on Saturday, May 21, on No. 28. This engine lurched and slipped much upon the Croydon line, but became steadier on the Brighton, which was in better order. She had no longitudinal motion, but was rough on the platform. She was stated to be five months out, and to consume 29 lbs. of coke per

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mile. Her driving wheels were 5½ feet, cylinders 14 inch, and 18 stroke.

There had been a little rain, and I observed the rails to be wet where the ballast was up to them, and dry where the spaces for drainage were. The down road I noticed was best in the Merstham tunnel, and worst in the Clayton. Except a few places, here and there, the road was in very good order. In the Merstham tunnel, I was struck with the very beautiful effect of the two long rows of gas-lights.

Another day I got on the *Merstham*, one of the oldest engines on the line. She has the same dimensions as No. 28, has much play in the axles, and lurches sadly. Her consumption of coke is 25 lbs. per mile.

Each engine, I was informed, ran a fortnight, and was in, three days. They run 122 miles one day, and 102 next.

I was subsequently on No. 27, which they say burns 22 cwt. of coke in 140 miles; No. 26, the *Satellite*, which burns 22 lbs. per mile, by Rennie, a fast and capital engine; No. 22, by Fairbairn, which was the six-wheel engine in the lamentable accident; No. 24; No. 9, an old engine, which lurched a good deal; No. 25, a much tighter engine, steady, and free from wriggle, longitudinal motion, or lurching; No. 29, by Fairbairn, an excellent engine for steadiness.

Monday, June 13, we tried the experiments on the curves already mentioned in my report, with No. 9, one of Sharp, Roberts & Co.'s, and No. 22, one of Fairbairn's, engines. The play of the wheels in No. 9 was 1.1 inch, and in No. 22 it was 0.9 inch.

I had an opportunity one day of getting on the four-wheel engine No. 17, which was at the accident just after the opening. She is now made into a six-wheel. She is 6 feet 1¾ inches from leading to driving axles, and 11 feet 2 inches from leading to trailing. We (the superintendent and myself) had been out to try her steadiness with another, a counterpart of her on four wheels. We ran them both with the same load, about a stage, each at a very rapid rate, but faster with the four-wheel. There was some difference, no doubt, in point of sinuous motion, in favor of the six-wheel, but nothing, we both agreed, that could amount to anything affecting safety. Indeed, had we stood anywhere but on the platform, where the checks of the additional pair of wheels to the vibrations must have been most felt, I doubt if any one but a very experienced hand could have discovered the least difference. From this trial I was satisfied that, as far as security goes, the additional pair of wheels is unnecessary.

The greater part of the engines of this company appear to be Sharp, Roberts & Co.'s. They are good, strong engines, but, in my opinion, there is too much rigidity and dead weight about them. They have also too great play in the axles, which causes them to lurch very much. Fairbairn's engines are longer and more flexible in the horn plates, and run infinitely smoother and steadier, though, except the lurching, which in some of them is excessive, Sharp, Roberts & Co.'s work very pleasantly.

The best engine, however, that I was on, was the *Satellite*, one of

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Rennie's. The workmanship and working of this engine are each excellent, and she is well adapted for taking a good load at a high speed. She cuts off the steam at two-thirds of the stroke. Her length of boiler is 8 feet, diameter of it 3 feet 4 inches; fire-box, length 2 feet 11½ inches, breadth 3 feet 6½ inches, height 3 feet 6 inches; smoke box, 2 feet 3 inches long, 4 feet 4 inches broad, 5 feet ½ inch high. She has 99 tubes of 2 inches diameter, 4 of 1.625 inch, and their length is 8 feet 5 inches. Her heating surfaces are 52 feet in the fire-box, and 450 feet tubular; area of steam passages, 15.12 inches, of exhaust pipe 24.06, and of blast pipe 8.29. Weight 16 tons—that is, 5 on leading, 8 on driving, and 3 on trailing, wheels; cylinders 15 inch, stroke 18; driving wheels 5½ feet, other wheels 3 feet 6 inches. To what pressure the valve is screwed I was not able to ascertain, in consequence of the curious manner in which the scale was graduated.

I am informed this engine has taken, without assistance, from London to Brighton, 15 loaded carriages, at 35 miles an hour. When I traveled with her, she was blowing off steam the whole way. Two circumstances contribute to her steadiness—the suppression of the back pressure from the size of the ports and blast pipe, and the placing of the suspending springs below the frame, by which the centre of gravity is lowered fifteen inches. She contains several minor improvements in the details, and is altogether a very excellent engine.

The engine-men have, as on the Birmingham and Gloucester, rewards for every pound of coke they save per mile, upon a certain amount, according to the engine. This excellent plan causes the men to be exceedingly careful, and saves a great deal to the company.

I have only to add that I have received every facility, in the prosecution of my labors, from the directors, secretary, and engineer, and, in general, from the officers and servants of the company. They seemed desirous that every information I could desire should be afforded me, and nothing withheld, or kept back. Railway Mag.

On the Causes of Injury to Steam Boilers. By C. W. Williams, Esq.

In my last paper on this subject, I explained some of the causes of those injuries to which steam boilers are exposed, and dwelt on the circumstance that the sediment assumes two distinct forms, namely, that of a solid crystalized incrustation, and of a loose mud-like body, held merely in suspension. I showed that the first could not be the cause of injury to the iron plates of the boiler, inasmuch as it was itself a good conductor of heat; whereas the second—the floating matter—would become a positive non-conductor, if allowed to subside, when the boiler had been at rest for some hours, and when it would assume the dry hard consistence of plaster of Paris.

I now propose to give further proofs of the conductibility of this solid crystalized incrustation, and draw some important inferences therefrom. I had two pins constructed, to act as conductors, each three inches long, and three-quarters of an inch square, one made of

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iron, and the other cut from a large slab of incrustation taken from the interior of a marine boiler. These were inserted into separate vessels, containing water, the one end projecting half an inch into the water, through the side, and the remaining part projecting outwards, to receive the heat from a powerful gas-burner. These vessels were so protected, that no heat could reach them, except what passed longitudinally, and exclusively through the conductor pins; consequently, the water received no heat except what was conveyed, by conduction, through those pins.

By means of the *iron* conductor pin, the water was made to boil in 13 minutes, and, by the *incrustation* conductor pin, in 17½ minutes. That the pins themselves were not raised to any inconveniently high temperature was proved by the fact, that, when suddenly removed from the flame, which was very intense, and while the water was fiercely boiling, the pins themselves were at a temperature so low as to allow the finger to be pressed against them without inconvenience; it certainly did not appear to be above 500 or 600 degrees—a temperature far too low to produce any injurious effect on their structure. This experiment resembled the well known one of taking a kettle, containing boiling water, from the fire, and placing it on the hand, for an instant, and without injury. I may here observe, that I was not able to discover any difference between the temperature of the two conductor pins.

Now, since no heat was received by the water, in either case, except what passed longitudinally through the conductor pins, it is manifest that the entire heat which raised the water to the boiling point, and maintained it in a state of active ebullition, must have passed through a vertical section of the side of the vessel, of but three-quarters of an inch square. This experiment, therefore, proved, first, that this three-quarter inch surface of the boiler plate was sufficient for the transmission of a quantity of heat out of all proportion greater than could have been transmitted by such area under ordinary circumstances; second, that this incrustation (which was crystalized sulphate of lime) possessed an admirable conducting property; and, third, that no possible injury could be sustained by the conductor itself, so long as its temperature remained so low.

The first of these facts shows how erroneous have been our previous modes of estimating the evaporative power of any kind of boiler, or fuel, by calculations drawn from the mere areas of the exposed plates; while it proves that much may yet be done in this department of the boiler. The second shows that, in this crystalized state of the deposit, it cannot be the cause of injury to the plates, although the uncrystalized, or loose, matter, if allowed to settle and become hard, becomes a mischievous non-conductor, and the direct source of injury from overheating and bulging. The third proves that, if the recipient body to which the heat is conveyed be able to absorb the heat as fast as it is passed through the conducting body, no injury can be sustained by the latter, seeing that this solid mass of incrustation, (hitherto supposed to be a bad conductor,) itself remaining unaffected, was equal to the conveyance of a very powerful heat,

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through no less than three inches; while, in fact, it never reaches to above half an inch in thickness on those parts of boiler plates which are exposed to the greatest heat.

Now to apply these facts, and the inferences to which they lead, to practice. We find that, so long as the water is maintained in contact with the plates through which heat is conveyed by conduction, no injury will be sustained. But the question arises—what is there to interrupt this contact, and what other recipients than water are to be found in boilers? In land engine boilers, no injury can arise to the plates from any circumstance connected with the furnace, or fuel, beyond the ordinary wear and tear, (the sources of which will be hereafter examined,) if due attention be paid to cleanliness in the interior, and maintaining the water at its proper level. Marine boilers, however, from their peculiarity of construction, are subject to another source of injury, and which is too often destructive of the plates connected with their furnaces, and the parts adjacent. This peculiarity consists of numerous vertical narrow passages. In these, the steam, as fast as it is generated, becomes, by reason of its ascending current, so mixed with the water, as seriously to obstruct the free and continued access of the latter to the plates. This also takes place to the greatest extent in those parts which are exposed to the highest temperature, since such ascending current of steam is necessarily the greatest where the heat is greatest, namely, in the side plates of the furnaces. The consequence is, that these side plates, through which the heat is conveyed to the interior of such narrow passages, are more frequently overheated and bulged than other parts, though exposed to even a still higher temperature from the direct action of the flame.

The heating of the side plates of the furnaces of marine boilers may, therefore, be said to arise solely from the circumstance, that, by reason of the conflicting currents of steam and water in those narrow passages, or water-ways, the recipient, being then a mixture of water and steam, (too often of the latter alone,) the heat cannot be taken up as rapidly as the metal conveys it, and the usual consequences of overheating necessarily follow.

This interposition of steam, where water alone should be found, and its inevitably injurious consequences, were strikingly illustrated in the first boilers of the transatlantic steam-ship, the *Liverpool*. In these boilers, the water spaces were above 5 feet perpendicular, and but 5 inches wide, thus leaving a space of but 2½ inches for the water approaching the side plates of each of the furnaces, and the steam generated by the heat received through such plates. This steam was necessarily so great in quantity as to prevent the access of the water, and, in fact, became itself the recipient of the heat from the furnaces; the consequence was, that the plates became overheated, bulged, and cracked, and extensive injury was sustained by them during every voyage. Not unfrequently they required to be wholly removed and replaced, at a considerable expense, before a new voyage could be commenced.

That steam, in fact, was the recipient of the heat in those narrow passages, where water should always predominate, was proved by a

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his voyages. He introduced a trial pipe in the space (erroneously, in this instance, called the *water*-space,) between two of the furnaces, and on a level with the fuel—the inner end opening into such space, and the outer end projecting outside the boiler, and being furnished with a stop-cock. The result proved his anticipation; for on trying this pipe, when the furnace was active, he could never draw off any thing but *steam*. This circumstance was conclusive, that although the water continued at its proper level in the boiler, yet, by reason of the confined nature of the passages, and the absence of a free circulation and access of the water, (at the very place, which, of all others, required its continual presence,) the steam, a bad recipient, had usurped its place. This source of injury continuing, the furnace side plates, as constantly were deranged, while the roofs and other parts remained sound to the last.

From the instance here adduced, it does not follow that any given width of water-space is necessary, or that narrow spaces must always be injurious. I have frequently observed that spaces of but three inches wide between the furnaces have been unattended with injury to the plates. The cause of injury, then, arising from the predominance of steam instead of water, is rather to be traced to other circumstances connected with the circulation of the water in the boiler, and the aids or impediments it receives from the peculiar construction or arrangement of the flues.

The main practical consideration, then, in seeking to protect the plates of boilers from overheating, is, that it is not to the fire, or furnace, that attention should be directed, but simply and solely to the nature of the recipient to which the heat is conveyed, for in this will be found to rest the whole question of injury. This will be objected to by those who have hitherto anticipated danger from hard firing and incrustation, and the want of due proportions between the fire and flue surface. Yet I state the position broadly, after the fullest investigation and the most conclusive proof, that, if we look to the recipient and its heat-absorbing properties, and attend to the interior of the boiler, and preserve all right in these respects, we shall do all that is practicable towards preventing injury from overheating, or what is erroneously termed "burning the plates."

Let us now inquire what are the several recipients of heat which present themselves in ordinary boilers. These are—

1. Water.
2. Steam.
3. Air.
4. Deposit crystalized.
5. Deposit uncrystalized.

The two latter have already been examined. I have now to speak of the three first mentioned, and this I will do in my next communication.

Liverpool, Feb. 7, 1842.

Lond. Mech. Mag.

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Concrete, its Introduction, Composition, Uses, and Comparative Expense.

Concrete was first used in this country by Sir Robert Smirke, at the erection of the penitentiary at Millbank, afterwards at the under-setting of the walls of the new custom house, and has been generally used by the abovenamed architect in the public buildings since erected under his care, especially at the club house of the Oxford and Cambridge University in Pall Mall, where the whole area of the building, and to the extent of two feet beyond the line of the lowest footing, was covered to a depth of 2½ feet, the depth being increased to four feet under all the walls that rise to the roof; in the specification of the last named building it is thus described. "For the grouted stratum, clean river gravel is to be provided, and mixed with lime ground or pounded to a fine powder; it is to be well mixed with the gravel, twice turned over before it is wheeled to the excavation, and it is to be thrown from a height of not less than six feet in every part. A man to be kept treading down and puddling the mass as it is thrown down; the proportion of materials to be six parts of gravel, to one of Dorking, Merstham, or Haling, stone lime." It has now become, in the present day, the most favorable expedient resorted to for artificial foundations. Mr. Ranger, of Brighton, improved the above hint by using hot water to facilitate the setting, for which he took out a patent for making artificial stone. A detailed account of the application of Mr. Ranger's artificial stone to the building of docks and river walls at Chatham and Woolwich, is given in the first volume of the Journal, being a paper by Lieut. Denison, from the Papers of the Corps of Royal Engineers. Analogous to concrete is beton, from which it differs in broken stone being used, instead of gravel, in the proportion of two of stone to one of lime, or pozzolana, of Italy; a description of which, taken from the Franklin Journal, appeared in vol. 3, page 265, of your valuable periodical. Since the introduction of concrete, some little difference of opinion as to the proportions of materials, and manner of mixing them, has arisen among engineers. I therefore give the composition from several specifications:—No. 1. The concrete to consist of five parts of clean gravel, perfectly freed from loam, or clay, with a proper proportion of small gravel and sand, as well as large, and one part of lime measured dry; the lime to be mixed into a perfectly smooth, uniform paste, as for the mortar, but with more water, and then thoroughly mixed with the gravel.—No. 2. The concrete to be composed of sandy gravel and well burnt lime, in the proportion of three of the former to one of the latter. The gravel to be free from all earthy matter, and the pebbles not to exceed one inch in diameter. The lime is to be used in a hot state when slaked, and to be immediately mixed, using no more water than is sufficient to incorporate them. After being twice turned, it is to be wheeled on to a stage ten feet high, and let fall into the trench; it is not to be puddled, or disturbed in any way, until perfectly set.—No. 3. All concrete must be composed of gravel, perfectly clean, and

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mixed with fresh, well burnt lime, in the proportion of six of gravel to one of lime. The lime and gravel to be mixed in a dry state, and a sufficient quantity of water afterwards added.—No. 4. Concrete to be composed of good lime, gravel and sand, in the proportion of one-seventh to one-ninth of lime, and it should be laid in about twelve inch layers, or courses, and pitched from a height of ten to twelve feet, neither should it be disturbed until properly concreted and set.

In the above five opinions, including that of Sir Robert Smirke, we have the relative proportions of gravel and lime, varying from three to nine; and No. 1 states the lime and water to be first mixed, in which No. 2 nearly coincides, whilst No. 3 insists on the gravel and lime being first mixed, and then the water added; Nos. 4 and 2 coincide that the concrete is not to be disturbed after it is thrown into the trench, whilst Sir Robert Smirke expressly says that parties are to be employed puddling the mass. The whole are agreed in specifying that the material is to be thrown from a height. From considerable practice and experience in the mixing of concrete, I think that the lime need not be ground, but simply mixed with the gravel, and then, by the addition of water, it will fall to an impalpable powder; also, that it is unnecessary to be at the expense of puddling the mass after being deposited in the trenches, neither is there any advantage to be derived from discharging the mixture from a height, both of which operations increase the expense of the concrete; and as the concrete in the act of setting expands in bulk, I think that alone a sufficient proof of the inutility of both of the abovementioned operations, their tendency being to condense the mass, whilst its own natural tendency is to expand. With respect to the proportion of lime and gravel, I think the less lime the better will be the concrete, and that the proportion of 8 to 1 of lime is decidedly better than 3 of gravel to 1 of lime. As to the quality of materials employed, the lime must be stone lime, fresh from the kiln; that from chalk will not do, and hydraulic, or lias, lime is to be preferred to stone limes. With respect to gravel, if obtained from a pit, the ochreous, or ferruginous, is to be preferred; and if loam is present, so as to soil the hand, the gravel must be washed; if the gravel be obtained from rivers by dredging, alluvial and vegetable deposits are to be avoided; and if the gravel contain vegetable refuse, it must be screened, or washed. Shelly, sharp gravel, is the best; the proportion of small or large pebbles, and the due quantity of sand, is soon learned with a little practice.

As to the uses of concrete, it is principally adopted as an artificial foundation, and from four to six feet is a sufficient depth, and extending two feet beyond the space to be occupied with the building. The following testimony of the utility of concrete is from Weale's Bridges, page 31: "Piling will probably never be found more safe than a body of concrete; the latter cannot be too much esteemed for its durable and almost imperishable nature, besides being quite as safe, and, perhaps, more durable, than piling;" and from the paper of Lieutenant Denison, before alluded to, we have the following ratification of its uses: "Concrete cannot be advantageously employed as a building material." "It may be employed with advantage in backing retain-

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ing walls." I. K. Brunel, Esq., C. E., has used concrete as a foundation, nearly exclusively and universally, in the bridges on the Great Western Railway; and, in the celebrated bridge of Maidenhead, the land arches are backed with concrete to the depth of ten and a half feet, and the abutments of the large arches are also backed with concrete. In culverts underneath embankments, the same able engineer has extensively used concrete as a backing material, the brickwork being kept thin, and then enveloped in a mass of concrete, in the form of a polygon, of six sides, or of the form of two truncated cones, with their bases joined.

Concrete was used on the Great Western Railway, wherever it could be employed, as a backing material; its use is now rapidly extending to the provinces, and bids fair to supersede all other means now employed for making a foundation; it is much improved by being mixed with oxide of iron, smiths' scales, and roasted iron-stone, or any material containing iron. As regards the comparative expense, brickwork, being the most common building material, has been taken as the standard of comparison with concrete for price; and its cost, in most districts, will be found from one-third to one-sixth the price of brickwork; taking a cubic yard as the quantity of each material, the latter will cost 5*s*., and the former 21*s*., both, to a great extent, being regulated by the vicinity of brickyards, and the facility of obtaining gravel. I have known concrete executed at 3*s*. 3*d*., 3*s*. 6*d*., 4*s*., 4*s*. 6*d*., 5*s*., 7*s*. 6*d*., 8*s*. 6*d*., and 11*s*. 6*d*. per cubic yard, although the most common price is 7*s*. 6*d*.; as to brickwork, the general price is 21*s*., and the range is from 14*s*. to 27*s*. 6*d*. per cubic yard; the London price being 25*s*. per cent. dearer than the country. The facility of obtaining lime regulates the cost of concrete; the price of lime per cubic yard, measured dry in clots, at Dorking in Surrey, is 11*s*.; Barrow in Leicestershire, 21*s*.; Bulwell in Nottinghamshire, 9*s*. 6*d*.; Breadon in Derbyshire, 15*s*. 6*d*.; Harefield in Buckinghamshire, 16*s*. 6*d*.; Fulwell, Durham county, 9*s*. The measures of lime, also, vary much; in some places it is sold by the cubic yard, measured dry, which is decidedly the best method adopted; it would be desirable if it was universal. It used to be sold in London, by the hundred, as it was called, not of weight, but a measure, a yard square, and a yard and inch deep, which will be equal to sixteen or eighteen bushels, but it is now sold by the cubic yard. The Fulwell and Barrow lime is sold by the quarter, eight of which make a ton and a half. Lime is also sold by the boll and chaldron; a chaldron will be about three and a half tons, a single horse cart about six bolls. In agricultural districts, the bushel, boll and quarter, are used; in colliery districts, the chaldron and ton are the standard of measure. With respect to the cost of gravel, provided it can be obtained on ground belonging to the company, the getting, screening and cartage, will cost 1*s*. 6*d*. to 2*s*. per cubic yard; if it be obtained from the gravel pits of the country, the charge will be, per ton, from 2*s*. 6*d*. to 2*s*. 9*d*.; if screened, 3*s*. 3*d*. to 3*s*. 10*d*.; if broken, 6*s*. 10*d*. A cubic yard will weigh from 24 to 27 cwt. If the gravel is dredged, or brought from the shores of a river, the cost will be 2*s*. 6*d*. per yard, or nearly the same as from the

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price of excavation is also included in the price of concrete in all railway specifications, which will be about 4*d.* per cubic yard, as, generally, the excavation is of limited extent, and, consequently, more expensive than an extensive excavation; and when the gravel is obtained on the ground of the company, or proprietor, the excavation is a double operation, the hole having to be refilled with other materials in lieu of the gravel obtained. From the experience of several thousands of yards and variety of situations, I find the cost of mixing the materials, or, as it is termed, concreting, to be 1*s.* per cubic yard, and, taking the proportion of material at 5 to 1, the following will be a fair estimate of the cost of concrete:

	s.	*d.*
1 cubic yard of lime,	12	6
5 do. gravel, at 2*s.* 6*d.*	12	6
Labor, mixing at 1*s.* per yard,	6	0
6 yards of excavation, at 4*d.*	2	0
Waste, contingencies and profit, at 1*s.*	6	0
6 cubic yards, at 6*s.* 6*d.* =	39	0

Concrete will set in twenty-four hours; the specific gravity is 125, or about the same as brickwork, although brickwork is sometimes 165 lb. per cubic foot. Lieut. Denison gives the strength of concrete $S = \frac{l\,W}{4\,b\,d^2}$. The constant S being 9.5, and comparing concrete to York paving, the proportion is as 1 to 13.

Civ. Eng. and Arch. Jour.

An Investigation of the Comparative Loss by Friction in Beam and Direct Action Steam Engines. By Mr. W. Pole.

This paper, consisting almost entirely of mathematical investigation, and involving the application of the differential and integral calculus, was read in abstract. Its object was, to show the futility of an objection frequently urged against the "direct action," or "Gorgon," engines, from their alleged increased friction. The results of this investigation appeared to be, that

The vibrating, or oscillating, cylinder engine has	a *gain* of 1.1	per ct.
The direct action engine, with a slide,	a *loss* of 1.8	"
Ditto, with a roller,	a *gain* of 0.8	"
The "Gorgon" engine,	a *gain* of 1.3	"

showing that the direct action engines, as generally constructed, and as adopted by the government for the steam vessels in the navy, has rather the advantage over the ordinary beam, or side lever, engines. In the conversation which ensued, it was agreed that the allowance which had been usually made for friction in steam engines had been

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over-rated; that, in reality, the friction rarely amounted to more than 1 lb. per square inch; and that, owing to the perfection to which the construction of machinery had now arrived, a further gain might be anticipated. Although the law of "friction being independent of the area of the rubbing surface," as given by Poisson and others, was impugned by some of the members, it was allowed, that as both kinds of engines had in the paper been treated analytically by the same rule, the results for both would, in an equal ratio, approach towards truth, and that, therefore, the conclusions arrived at might be received as correct.

The author further explained the nature and objects of his paper, which had not been fully understood, and illustrated the mode of analytical reasoning by which he had arrived at his conclusions. He then proceeded to answer the objections which had been raised against the laws of friction adopted by him, and to comment upon the mode of experimenting of Vince and others; showing, on the other hand, by quotations from the recorded experiments of Amonton, Coulomb, Rennie, and Morin, and from the works of Gregory, Brewster, Emerson, Playfair, Barlow, Farey, De Pambour, Poisson, Pratt, Whewell, and Mosely, that the views he had taken were correct. He also noticed the variations produced by attrition, and by the introduction of unctuous substances between the rubbing surfaces. These views were corroborated by several members present, some of whom had been quoted as authorities, and the propositions involved appeared to be generally received.—*Trans. Inst. Civ. Eng.*

Lond. Athenæum.

Machinery for Excavating, or Cutting, and Removing Earth.

Many have been the attempts to supersede, by means of machinery, the use of hand-labor in the tedious and laborious operations of cutting and removing earth, for leveling inequalities of the surface, forming canals and docks, and clearing the beds of rivers. These mechanical contrivances have necessarily partaken of the same general features, viz., moving peckers and shovels, or scoops, constructed and arranged in various ways, and actuated by wheels and levers, in a variety of forms and combinations, from the simple and well known dredging apparatus, commonly worked in our harbors and rivers, to the elaborate and gigantic new American excavator, which, under the absurd cognomen of the "Yankee Geologist," has been proclaimed to the world as capable of removing mountains.

Without intending, in the slightest degree, to detract from the merits of this American invention, which we hear from disinterested parties, who have witnessed its performance, to be one of paramount importance and vast capability, we think it necessary, in order to qualify the extravagant statements given in some of the periodicals of the day, both foreign and English, respecting its astonishing powers, to state what are the leading points on which its claims to novelty are founded.

In order to show this more clearly, it will be desirable to mention,

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in a brief way, the objects and features of the several machines for excavating and removing earth, which have been the subjects of patents within the last twenty years. The first of these we find to be the invention of George Vaughan Palmer, of Worcester,—a machine to cut and excavate earth, granted 8th June, 1830. This machine is mounted upon wheels, intended to advance upon a temporary railway, laid upon the surface where the excavation is to be made, beneath which a hole is dug to commence the operations in. There are a number of peckers in front of the machine, which, by vibratory action, dig into, and thereby break up, the earth. A consecutive series of buckets, connected by an endless chain, are brought down into the disturbed and broken ground, and scrape up the soil, stones, &c., which are carried away up an inclined plane, in the manner of the ordinary dredging apparatus. The machinery is worked by a winch and toothed gear, and advances upon its railway as the earth is broken and removed.—See Vol. VII, page 314, of our Second Series.

Sir Thomas Cochrane, Knt., obtained a patent, 20th October, 1830, for apparatus to facilitate excavations, sinking and mining; but this is a pneumatic contrivance, merely to prevent the percolation of water into a tunnel, whilst in progress of formation. See Vol. VII, page 304, Conjoined Series.

Mr. G. V. Palmer, of Worcester, had a second patent granted, 24th January, 1832, for improvements in machinery or apparatus for excavating, and which he called an excavating and self-loading cart. This contrivance much resembled an ordinary cart upon two wheels, drawn by horses. Under the cart were placed the cutting, or excavating, instruments, formed something like the share and breast of a plough, which excavators were capable of being lowered, so as to take into the ground and break up the soil to any required depth, as it advanced; or they might be drawn up out of operation, in order to allow of the cart traveling on ordinary roads, when proceeding to, or returning from, its work. The running wheels of the cart were broad, and their felloes hollow, and in these hollows were transverse partitions, formed by plates, which constituted the bucket wheels. On the cart advancing, the ploughs, or cutters, penetrated into and broke up the ground, and turned the soil sideways into the buckets of the running wheels, which, as they revolved, raised the soil, and, in turning over, let it fall on to inclined edges, by which it was conducted into the cart.—See Vol. I, page 278, Conjoined Series.

In December, 1833, a patent was granted to Mr. Thomas Affleck, of Dumfries, for his invention of improvements in the means and machinery for deepening and excavating the beds of rivers, removing sand-banks, bars, and other obstructions to navigation. This, however, consisted merely of apparatus, which, when agitated by the rolling waves, or rise and fall of rivers, disturbed and broke up the mud, sand, or gravel, for the purpose of enabling it to be washed away by strong currents, or freshes.—See Vol. IV, page 273, Conjoined Series.

An apparatus to facilitate and improve the excavation of ground, and the formation of embankments, invented by Mr. William Brun-

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November, 1838. A part of this invention was a series of hook-shaped cutters, fixed in a frame, one in advance of another, and which, being connected to machinery, were forcibly projected into the ground, and made to plough it up in grooves; each cutter, as it advanced, cutting and preparing the way for the next cutter in succession. The other parts of the invention applied to the arrangement of stages, and the order in which a series of workmen were to dig and remove the soil. Also, the manner of depositing soil for the formation of embankments; compressing it to give solidity; and conducting the earth-wagons, upon tram-ways, by endless ropes.—See Vol. XVII, page 284, Conjoined Series.

Mons. L. J. A. Ramel, a foreigner, obtained a patent in England, dated 19th March, 1838, for his invention of improvements in machinery for excavating and embanking earth, for the construction of railways, and other works. The specification of this patent does not set out in very clear terms what are the features of novelty proposed, but speaks of the "system of a lever." As far as we can understand the subject, it seems to be merely the adaptation of a long lever as a crane, which works vertically, to raise loads of earth in a box, in place of employing hand-barrows, passing up inclined planes, or of pitching the earth from stage to stage by hand-labor. This lever is mounted upon a platform, with running wheels, for the convenience of passing it from place to place, upon a railway; and the lever, to one end of which the loaded box is attached, is worked by a cord, or chain, connected to the other end, and to a winding drum, or barrel, and windlass; and when the load of soil is conducted to the place of deposit, it is let fall into a cart, by opening the bottom of the box.

An invention of certain improved machinery for cutting and removing earth, was communicated to Mr. William Newton, of Chancery Lane, by a foreigner, for the purpose of obtaining a patent, which was granted on the 27th March, 1839. This invention is a peculiar arrangement and construction of apparatus, mounted in a carriage upon a temporary railway, in which a series of rotary cutters, or peckers, working in inclined positions, are made to break the ground below, at an angle of about forty-five degrees, as the carriage proceeds; and also to throw the earth, thus broken, into a consecutive series of buckets, attached to an endless chain, which, by traveling vertically, takes up the broken earth to the top of the excavation, and delivers it into a series of troughs above, which troughs, by moving in a transverse direction, carry away the earth and deposit it in carts, or otherwise, as convenience may require.—See Vol. XVI, page 57, Conjoined Series.

Mr. W. Scamp, of Woolwich, obtained a patent, dated 16th February, 1841, for an application of machinery to steam vessels, for the removal of sand, mud, soil, and other matters, from the sea, rivers, docks, harbors, and other bodies of water. This invention consists merely of a barrel, studded all over with spikes, which, being mounted upon an axle, was suspended by lever arms from the vessel, and, on being lowered down to the bed, or bottom, of the river, the barrel

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was made to revolve, as the vessel advanced, by a traveling endless chain, extending from a pulley, or spur wheel, on the axle of the propelling wheels; or, by other rotary means, to a pulley on the axle of the barrel, so as to cause the mud, sand, and other materials on the bottom, to be disturbed, or broken up, by the spikes, and, on mixing with the water, to be carried away by the current.

These are all the schemes which have been proposed and brought before the public, under the protection of letters patent in England, within the last twenty years, until the introduction of the American invention above alluded to.

This machine, which we are not permitted at present to lay before our readers in all its details, consists of a horizontal platform, mounted upon wheels, carrying a strong jib-crane, and also a steam engine. From the end of this jib-crane, the excavating tool, or cutter, is suspended by chains and pullies, which allow of its swinging in a forward direction; and the back part of the tool, or cutter, is attached to a rod, or beam, sliding on rollers, which, being acted upon by chains and toothed wheels, in communication with the steam engine, causes the cutter to be projected, with great force, against the earth required to be broken up.

The mechanism and the suspending chains, connected with the steam engine, and with the projecting rod, or beam, affords the means of regulating and determining the course in which the cutting tool shall move forward; and by means of a small hand-lever, a workman, standing upon the platform, is enabled to direct the advancing cutter through the ground, in a horizontal line, or through any inclined, or curved, course, up to a perpendicular; the movements of the pendulous chains determining the course of the cutter, whilst the sliding beam projects it forward.

The excavating tool is formed as a scoop, with strong tangs, or teeth, in front, to break the earth as it enters, and a sharp cutting edge to take up the broken fragments.

The machine having been moved upon its railway to the place where it is required to excavate, the platform is then made fast, pro tem., in that situation, and the steam power of the engine brought to act upon the mechanism, by sliding clutches, or other contrivances. The pendant tool, or excavator, is then forced forward by chains, connected to the projecting beam, and passed round a rotary drum, driven by gear from the engine; and, at the same time, the pendant chain is drawn up, or let out, as may be necessary, to allow the excavator to advance in the required course. When the projecting beam has carried the excavating tool forward to its extent of action, in a horizontal cut, the suspending chain, from the crane-jib, will raise the loaded scoop, (or the projecting and raising of the scoop may be simultaneous, as the workman shall direct,) which loaded scoop, when brought to its highest position, may be conducted to one side of the excavation by the swinging jib, and the contents let fall into a cart, by opening the back of the scoop; all which operations are effected through the agency and power of the steam engine, under the direction and regulating hand of the workman.

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It is only necessary further to say, that, by turning the jib of the crane to the right or left, the cutting of the earth may be performed at any angle to the direction of the machine, and, consequently, to a very considerable extent,—viz., a circuit of forty or fifty feet,—without shifting its situation; but when a change of place becomes necessary, the fastenings by which the platform was secured must be withdrawn, and the power of the steam applied to move the whole, upon its turning wheels, to the next place where it may be required to be made stationary.

Having given this brief description of the construction and mode of working the new American excavating machine, we conclude our present report by stating the points of novelty which it may fairly claim over others that have preceded it. Firstly, it is locomotive; its movements, and all its operative parts, deriving their powers from the steam engine which it carries. Secondly, that the earth is broken up and carried away from the place excavated by one instrument, (the scoop,) acting with immense effect, through the power and agency of steam. Thirdly, that the cutting may be made with equal facility at any inclination to the horizon, and to a great extent around the spot on which it is stationed, by the direction of the workman, without requiring to be moved from its place. Fourthly, that, by this machine, a channel may be cut through a hill, with the proper slopes for its sides, and a level base correctly formed, the excavated earth being simultaneously removed. Fifthly, the capability of cutting many feet below the base on which the machine runs, by lengthening its chains and guide-beam; which last feature renders it also applicable to working under water, when placed in a vessel, for removing sand-banks, bars, and beds of mud.

The engine and boiler, by which the various parts of the machine are put into operation, are shown at A B.—*a a* is the framework, provided with wheels, by means of which the whole apparatus is capable of being moved along a temporary railway, as the machine digs away and removes the earth before it. The crane-post is shown at *b b*, at the upper end of which is placed the crane-jib *c c*, supported by the diagonal beam *d d*, which is also used for carrying certain wheel-work and apparatus for effecting the required movements of the shovel. At each end of the crane are mounted pullies, over which a chain, *e e*, passes from the shovel, or excavator, *f*, and from thence down the centre of the crane-post, and under the carrier-pulley, *g*, to a windlass, or capstan, on the axis of which is mounted a large toothed wheel *h*, taking into a pinion upon the main driving-shaft, on which is mounted the fly-wheel *c*. The shovel, or excavator, is connected by swing-joints to the forked end of diagonal arms *i i*, which are furnished with chains, attached to each end thereof. These chains pass once round pullies, mounted upon the axle of the toothed wheel *k*; and hence, on rotary motion being communicated to the said axle, the diagonal arms *i i*, and consequently the shovel *f*, will be caused to move upwards or downwards. The end of the shovel is connected by hinges to the other parts thereof, and retained in its proper position, during the operation of digging, by means of a bolt, or pin, which

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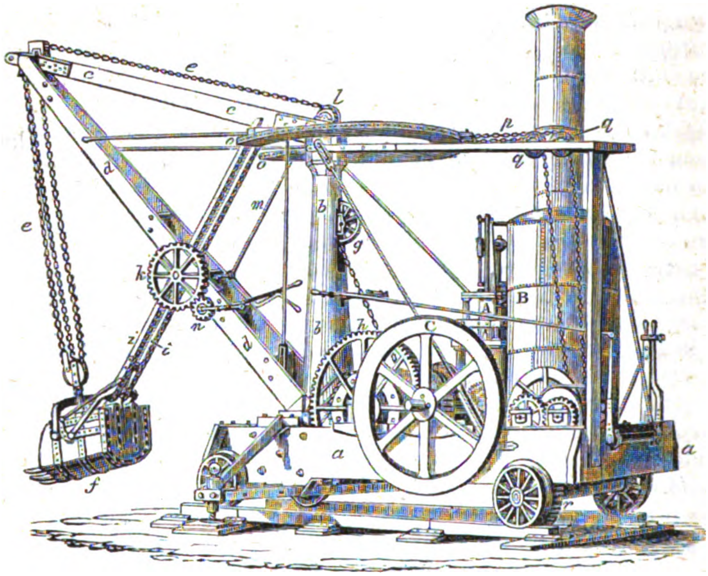
may be withdrawn, by means of suitable apparatus, when the filled shovel is raised by the chain *e e*, and swung round to the required position; the shovel will then tilt over, depositing the excavated earth in a wagon, or other required receptacle.



Upon the axle of the guide-pulley, on the top of the crane-post, is a beveled toothed wheel *l*, taking into a similar wheel, mounted upon a diagonal shaft *m*, at the lower end of which is a beveled pinion, taking into another, mounted upon the axle of a pinion *n*, which latter pinion is capable, by means of hand-levers, of being shifted in and out of gear with the wheel *k*; by which arrangement, the chain *e*, passing over the guide-pulley, and communicating rotary motion thereto, will cause the pinion *l*, and shaft *m*, to revolve, and thereby, through the intervention of the pinion *n*, and wheel *k*, effect the required motion of the diagonal arms *i i*, and shovel *f*, the attendant being able to arrest the motion thereof, at any time, by means of the hand-levers connected to the pinion *n*.

The horizontal motion, or swinging round, of the crane is effected by means of the horse-shoe shaped pulley *o o*, affixed to the crane by cross-rods; to this pulley each end of a chain, *p p*, is fastened, which chain, having passed round the periphery thereof, is conducted downwards, by means of guide-pullies, *q q*, passing once around an axle, driven by wheel-work, connected to the engine, which wheel-work is capable of being shifted in and out of gear with the main shaft, by the attendant, through the intervention of a hand-lever; by this arrangement, the chain, *p p*, is put into motion at discretion, thereby causing the horse-shoe shovel, *o o*, to revolve, and, with it, the crane

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and shovel, or excavator. The machine is propelled along its temporary railway, as the work progresses, by means of a toothed wheel *r*, affixed on the axle of one pair of running-wheels, and connected to the motion of the engine by suitable gearing.

When the operation of excavating commences, the shovel is caused (by the loosening of the chain *e e*) to assume a nearly perpendicular position, the teeth thereof being turned towards the earth; motion then being communicated to the several parts, by means of their respective trains of wheel-work, the chain *e e* is gradually drawn tight, and wound around the capstan, or windlass; during which operation the arms *i i* are brought into action, forcing the shovel into the ground by the means before described; hence it will be perceived that the shovel, or excavator, is operated upon by power exerted in two directions, the one through the medium of the arms *i i*, causing it to be thrust into the earth, the other through the medium of the chain *e e*, and its appendages, causing it to be lifted therefrom; by which combined action, and suitable speeds of driving gear, the shovel will describe a curve in ascending, the commencement thereof being just in front of the machine, and the end thereof vertically under the front of the crane-jib. The shovel being filled with earth, and raised to this point, is swung round, by means of the horse-shoe shaped pulley *o*; and the bolt, which secures the ends thereof, being withdrawn, the contents will fall into the wagon, or other required receptacle; after which, the crane is again swung round, and the various parts put out of gear, when the shovel will descend, in order to operate upon the earth as before.

This peculiar arrangement of apparatus, it will be seen, is applicable only to operations performed on land; but a machine on the same principle, suitably modified for the intended work, has been constructed for the purpose of dredging harbors, deepening rivers, or other such operations, a description of which, with a more minute account of the first machine, we shall lay before our readers at a future time.

Lond. Jour. Arts & Sci.

Notice of the great Explosion at Dover. *By* Captain Stuart, *7th Royal Fusiliers.*

An operation in engineering was successfully performed near Dover to-day, which, from its magnitude and novelty, must be a subject of deep interest to every person acquainted, in the least degree, with practical science. It was the removal of an enormous mass of the cliff, facing the sea, which formed an obstruction to the line of railroad. To give you a distinct idea of its position, it may be necessary to inform you, that a portion of the cliff which was penetrated by the tunnel made through Shakspeare's Cliff, gave way about two years ago. About fifty yards of the tunnel were carried away, and a clear space was so formed for the line of railroad, with the exception of a projecting point, which, prior to the slip alluded to, was the extremity of the part of the cliff pierced by the tunnel, and to remove which was the object of the operation in question. Mr. Cubitt is the engineer

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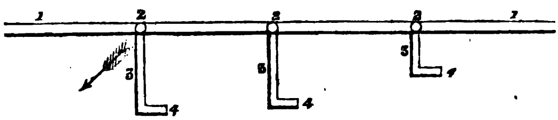
under whose management it took place. The expense of clearing it away, by the tedious process of manual labor, would have exceeded £12,000; and this consideration, as well as the time that would have been lost, induced him to try the bold experiment of blowing it away with gunpowder. It cannot be denied that there was apparent danger in the undertaking, for the weight of the mass to be removed was estimated at 2,000,000 tons, and the quantity of powder used was more than eight tons, or 18,000 lbs. 12,000 lbs. was the quantity used in blowing up the fortifications of Bhurtpore; and this, I believe, was the greatest explosion that ever (previously) took place for any single specific object. I had several opportunities of seeing the preparations for this grand event. The front of the projection was about one hundred yards wide; this front was pierced with a tunnel about six feet in height, and three in breadth; three shafts, equidistant from each other and from the entrances to the tunnel, were sunk to the depth of seventeen feet; and galleries were run, one from each shaft, parallel with each other, and at right angles with the line of the tunnel. These galleries varied in length, the longest having been 26 feet, the shortest 12 feet; and, at their extremities, chambers were excavated in a parallel direction with the tunnel. The following rude sketch may give a clearer idea of it.



1. The Tunnel. 2. The Shafts. 3. The Galleries. 4. The Chambers.

In the chambers, the powder was deposited in three nearly equal quantities; it was done up in 50 lb. bags, and the proportion in each chamber was contained in a wooden case, nearly as large as the chamber itself. Ignition was communicated by means of a voltaic battery. Conductors, 1000 feet in length, were passed over the cliff, one to each chamber, and the electric fluid was communicated in a shed, built for the purpose, on the top of the cliff, about fifty yards from the edge. The explosion was conducted by Lieut. Hutchinson, R. E., who, you may recollect, was engaged, under General Paisley, in blowing up the wreck of the Royal George. Two o'clock, P. M., of this day, the tide being then at its lowest ebb, was fixed on for the explosion to take place. The arrangements were the best that could be made to preserve order, and, as far as possible, prevent danger. A space was kept clear by a cordon of the artillery, and the following programme was issued.

Signals, January 26, 1843.

1st, Fifteen minutes before firing, all the signal flags will be hoisted.
2d, Five minutes before firing, one gun will be fired, and all the flags will be hauled down.
3d, One minute before firing, two guns will be fired, and all the flags

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(except that on the point which is to be blasted) will be hoisted again.

These signals were given exactly at the specified time, and, when the expected moment arrived, a deep subterranean sound was heard, a violent commotion was seen at the base of the cliff, and the whole mass slid majestically down, forming an immense debris at the bottom. The success of the undertaking equaled the most sanguine hopes, and exceeded the expectations, of all. It was a splendid triumph of skill, and reflects the highest credit on Mr. Hutchinson and Mr. Cubitt.

Dover, Jan. 26, 1843. Edinb. New Philos. Jour.

On the Introduction into Scotland of Granite, for Ornamental Purposes, by Messrs. Macdonald and Leslie, of Aberdeen. By Professor TRAILL, F.R.S.E., M.W.S., &c. &c.

The first idea of employing the refractory, but enduring, material, granite, in sculpture, appears to be due to the ancient Egyptians. Those who have enjoyed opportunities of examining their colossal buildings, have acknowledged the precision, and even delicacy, of the figures and ornaments with which that ingenious people contrived to enrich their architecture. Specimens of their sculpture in granite, which have for three thousand years resisted the action of the elements, and the yet more destructive influence of barbarous invaders, still astonish us by the high polish of their surfaces, and the delicate finish of their details. Even a visit to the Egyptian Saloon of the British Museum will prove that, in accuracy of muscular delineation, and in the communication of absolute *fleshiness* to the lips and features of some of the figures there preserved, the ancient Egyptians evinced a high perfection in the art of sculpture, in a material of the most imperishable kind, on which few succeeding artists have ventured to employ the chisel.

In our own times, the fabrication of slabs, pedestals, and vases, in hard porphyries, and in granite, has been carried to great perfection in Sweden. The quarries of Blyberg, at Elfdalen, for many years, have furnished materials for Swedish ingenuity and skill. The elegant forms and high finish of their works in those refractory materials, have contributed greatly to the splendor of the Swedish capital, and are known and admired over Europe. Yet, though our own mountains yield no less beautiful and durable materials, it is surprising how long we have remained without any attempt to apply them to the purposes of ornamental art. It is true that, for more than half a century, Aberdeen has exhibited a city chiefly built of hewn granite; that, more lately, this same material has been employed in the construction of Waterloo Bridge, in London, and in a few other works; and that Cornish granite appears in the pedestals of a few statues in some of our towns. But the idea of giving a polish, equal to that of

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saloons, and as lasting memorials of departed worth in our cemeteries—is undoubtedly due to two citizens of Aberdeen, Messrs. Macdonald and Leslie, who carry on extensive works in that town, where the gray granite of Aberdeen, and the rich red granite of Peterhead, are cut into an endless variety of ornamental articles, which receive the highest polish.

A late visit to their establishment convinced me that these gentlemen have reduced to practice the difficult problem of giving any required form to so stubborn a material as granite, and of communicating to its surface an exquisite polish, which show it to be well suited for domestic ornament, and as a superb decoration for the abodes of rank and opulence. The rich warm tint of the Peterhead granite, in particular, will harmonize better with the gilded ornaments and gorgeous hangings of a modern gallery, or superb saloon, either as tables or as pedestals for works of art, than furniture made of the most costly woods, or even than the snowy marble of Carrara.

For monumental work, this enduring material possesses advantages over the best marble. In our climate, the effects of rain, sudden frosts, and succeeding thaws, are soon perceptible on Carrara marble, or any other kind, exposed freely to the weather. Marble thus soon loses its glossy surface; it contracts greenish stains from the vegetation of minute *Byssi;* and inscriptions, in a few years, from these causes, become illegible. The polished granite of Aberdeenshire retains its polish most perfectly under all atmospheric changes, does not contract any stain from vegetation, and, unless wantonly mutilated, will transmit the inscription engraven on it to distant ages. The sharpness of the Egyptian hieroglyphics, carved in a very similar rock, three thousand years ago, at this day, proves the durability of granite carving. A beautiful cenotaph of red granite, from the works of Messrs. Macdonald and Leslie, has been exposed to all the vicissitudes of our changeable climate, for six or seven years, in the churchyard of Falkirk, and appears in the full lustre of its original polish, as if it were erected yesterday.

Fine specimens of granite monuments, by the same artists, may be seen in the noble new cemetery at Glasgow, which are chaste in design, beautiful in execution, and seem calculated to bid defiance to every destroying influence, except wilful injury.

On visiting the establishment of Messrs. Macdonald and Leslie, at Aberdeen, I saw several finished specimens, and many works of this material in progress, as I was conducted through the different departments, by the intelligent and most respectable head of this interesting and new employment of national art and industry.

The gray granite is of a close grain, and contains more mica than the red. It is brought from quarries on the Dee, a short way above Aberdeen. The red granite is of a larger grain, abounding in felspar and in quartz, intermingled with small specks of mica, and bears a strong resemblance to the syenitic rock of which the finest ancient Egyptian monuments are fabricated. This comes from the vicinity

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of Peterhead, and is brought by sea to the works. Both are susceptible of a fine polish, which they retain unimpaired by the weather. Blocks of almost any size may be obtained free of flaws, or imperfections. In the sawing room, several blocks were then under the machines, which are moved by a 14-horse power steam engine. I observed one block, ten feet long, cutting into six or eight slabs. The saws are, as usual in such works, of soft iron plates, secured in a frame, and operate on the stone by means of quartz-sand and water, applied as in slicing marble. No emery is requisite in these operations, the particles of siliceous sand being sufficient to cut the quartz, the hardest material in the granite. Frequently, fourteen saws are used in a single frame, and occasionally they have had as many as eighteen employed at once on a single block of stone. The progress of the work, of course, is slow; it requiring a whole day to cut a groove, two-thirds of an inch in depth, in the granite. The slabs, when cut, are polished by moving one over the other, by appropriate machinery; siliceous sand being first interposed, and then emery, of various degrees of fineness, until the requisite degree of lustre is obtained.

The first dressing of the granite blocks into parallelopipeds, cylindrical masses, or other curved forms, is performed by *hand-picks*, with short handles, and heads about four pounds in weight, which the workmen, from long habit, wield with surprising accuracy. The surfaces are then reduced to a regular form, by means of well-tempered chisels, urged by iron mallets; the chisels require a very particular temper, which must be neither very hard nor very soft, else they would either lose their edge by *chipping*, or fail to cut the stone. I observed that they frequently require sharpening in the more delicate kinds of work. The chisel is held by the workman very obliquely to the surface of the stone, and he separates very small particles at a time.

I have already described the polishing of plane surfaces. Circular forms, such as *stelæ*, frusta of columns, as pedestals for busts, vases, and the like, are fixed in well-contrived lathes, and are whirled round by machinery, while the sand and emery are applied to their surfaces by means of thick plates, or bars, of iron, previously forged to their various curvatures, when they are not cylindrical.

I saw a large vase, about four feet in diameter, prepared by the chisel for the process of polishing. Its graceful curves were beautifully and accurately cut by the chisel; the iron bars, 1 or 1¼ inch in thickness, neatly forged to its various curves, lay beside it, ready to be applied when it was fixed in the lathe.

In the warerooms were many finished articles of great beauty and elegance, such as well-executed pedestals for busts, or vases, of red and gray granite; chimney pieces of the same material, numerous slabs, tables, and seats for halls, and beautiful vases, in a considerable variety of forms, rivaling those of classic Italy in shape, mural tablets for monuments, and some altar-formed tombs of magnificent size. These last were made to order. Some of the chimney pieces are in-

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some of the slabs for Sir Robert Peel, &c. &c.

I was surprised at the neatness of the *lettering* on all the monuments, and saw the men at work. The monument is first finished in other respects; the letters are carefully traced with a dark, or light, crayon, according to the color of the stone, and the workman traces the outline of the letter on the stone by light strokes of a fine-edged chisel, held nearly vertically; deepens the lines by a succession of similar blows, while the chisel is held very obliquely, removing the stone in the state of powder, so as to avoid chipping. Roman capitals are thus easily formed; but I saw old English, or German, letters, with a superfluity of curved lines, carved on the granite with equal precision.

But the most remarkable work which I saw in this establishment, was the neatly finished statue of the late Duke of Gordon, intended to be erected in one of the streets of Aberdeen. It is 11 feet high, of a single block of granite. This statue was modeled by Mr. Thomas Campbell, the sculptor, and has been transferred from the model to the granite by Messrs. Macdonald and Leslie. Two men were at work on the drapery, at the period of my visit. They worked with fine chisels, held very obliquely, and urged on by iron mallets of two or three pounds in weight. The attitude of this statue is simple, and the features are said to be very like the original. This, which may be considered as the first specimen of a British statue of a single block of granite, in emulation of the durable monuments of ancient Egypt, is a memorial by the county to the late noble and gallant officer, and, when erected, will be a distinguished ornament to Aberdeen.

Another great public work, executed by the same artists, is already erected in that town. In 1842, the splendid public markets of Aberdeen, excelled by none in Europe in elegance, were opened. The great saloon, containing the fruit and vegetable market, a magnificent hall, 300 feet in length by 100 feet in breadth, has within it a noble fountain of highly polished Peterhead granite. An octagonal basin, constructed of polished blocks, stands about one-third the length of the hall from the southern extremity. From the centre of this basin rises a shaft, ten feet high, supporting two circular cups, or shallow vases, one placed over the other. The lowermost is formed out of a single block, seven feet three inches in diameter, and the upper has about half that width. A constant jet of water rises from the centre of the upper cup, flows over its edges into the lower vase, which also overflows, in a thin sheet of limpid water, into the basin below, whence water is drawn for all the purposes of the market. I have seen no fountain in Britain so fine as this. It resembles in form, and surpasses in material, the finest fountains I saw in Spain; yet it was erected by Messrs. Macdonald and Leslie for £200.

The same artists are at this moment engaged in executing a similar monument for Lord Prudhoe, which, I understand, will cost about £200.

Indeed, considering the difficulty of working so hard a material, I

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was surprised at the moderation of their prices, for articles produced at their interesting establishment.

For instance:—

1. A hall-table slab of polished granite, measuring 4 feet long by 21½ inches wide, costs £4 15s.

It may be stated, that slabs may be furnished, of any required size, for from 12s. to 14s. for each square foot of surface.

2. Pedestals for busts, square or columnar, with plinth, and an ovolo when columnar, of the usual size, for £10.

2. Mural monumental tablets, with vase, trusses, &c., from £6 to £9, according to the size.

4. Mural tablets, with base, cornice, and pedimented top, from £10 to £12.

Lettering, of the usual size, is charged 4s. 6d. per dozen of letters.

5. An elegant *Tazza-formed* vase, of classic shape, 4 feet 9 inches in diameter, and standing 2 feet 9 inches high, on a beautiful pedestal, costs £40.

6. They have also executed columns of granite, for halls and vestibules, at prices equally reasonable, in proportion to the size and style of decoration. But of all the purposes to which they have hitherto applied the granite, it seems especially suitable for monuments of every kind, both from the beauty of the highly polished material, and its imperishable nature under all vicissitudes of the weather.

The extent and perfection to which these gentlemen have carried the working of this very refractory, but beautiful, stone, may be considered as forming an era in British art, and require only to be more generally known, to be appreciated and encouraged by public taste and munificence.

Edinburgh, March 18, 1843. Ibid.

Roof over a Panorama.

The first paper read was a "Description of the Roof suspended over the Panorama in the Champs Elysées, Paris," by M. Hittorff. The Hon. Secretary, Mr. Bailey, observed, that although the Germans attribute the invention of panoramas to Prof. Breisig, of Dantzic, it is generally admitted that they are of English origin, and that the first was exhibited in 1793, by Robert Barker, in the city of Edinburgh. The most important building for such exhibitions, one far surpassing any at that time existing in foreign countries, was erected in London by Mr. T. Horner, and is known as the Colosseum, Regent's Park. The plan is a polygon of sixteen compartments, whose interier diameter measures about 123½ feet. The dome is constructed of timber, curved and arranged upon the principle of Philibert de Lorme, and is covered with copper. In the centre of the building are two concentrical cylinders, supporting three galleries, as well as supporting the centre of the dome, or roof. The rotunda, since erected in Paris, surpasses in magnitude even this vast edifice. Among the various designs for embellishing the Champs Elysées, M. Langbois suggested

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the idea of a rotunda for the exhibition of panoramas. The ground was granted to him for a term of forty years by the Municipal Council, on the following conditions:

1. The diameter of rotunda to be 130 feet.
2. The roof to be conical, and without a central kingpost.
3. The rotunda to be lighted by a cycle of glazed sashes.
4. The intervention of any obstruction between the sashes and the wall of the rotunda (thereby casting a shadow upon the canvas) to be carefully avoided.
5. And, finally, all these data to be severally complied with at the least possible expenditure.

Considering the difficulty of constructing a building of such dimensions without a central kingpost, and the great expense of arched timberwork, together with the solid structure of the walls, indispensably requisite to resist the thrust of the wooden vault, the artist resolved to apply (in the construction of the new building) the principle of suspension adopted for bridges, by means of chain cables. The site of the rotunda not allowing of the adoption of stays, fastened at a distance from the building, it was necessary so to contrive the buttresses that they should hold the cables and resist their tension. Their number, amounting to twelve, gives a subdivision of the wall of the rotunda into arcs; and it may be considered, at the level of the stone cornice, as a polygon, whose sides adjacent to one and the same buttresses, offered a two-fold force opposed to the strain of the cables. In this way the resistance was obtained nearly at the expense of the cornice and the wall; and by adopting two circles, with the cables passing between these circles, the upholding chains can be strained as required. These cables pass at an angle upwards, over vertical rods, which rest on pivots on the inner edge of the cornice wall, which is about 3½ feet in thickness; they then rest on the outer edge of the cornice wall, and the ends of the cables are carried to the abutment walls, and are there fastened. The building was commenced in October, 1838, and covered in January, 1839. It attains a mean height of nearly 50 feet, occupying a surface of nearly 21,653 square feet, and its circumference is composed of a mass of building above 16 feet in depth, having three stories distributed into apartments over a space of 520 feet; and the cost of the whole was about £13,000.—*Inst. of Brit. Arch.*

Lond. Athenæum.

Bridge over the River Wear.

The next paper was by Mr. D. Bremner; it contained a description of the stupendous bridge over the river Wear, on the line of the Durham Junction Railway, which connects the city of Durham with Newcastle, South Shields, and Sunderland, and is now destined to form a portion of the great chain of railway towards Edinburgh. It is built on the spot originally selected by Mr. Telford for a bridge on the line of the projected great road to the north; it was designed by

Alcantara, and, with some modifications to suit the locality, has been constructed, under Mr. Harrison, the engineer of the railway, by Messrs. Gibb, of Aberdeen, whose perseverance and skill in the execution of the structure, and in contending with the difficulties of it, are highly to be praised. The bridge consists of four nearly semicircular arches, of 160 feet, 144 feet, and two of 100 feet, span, respectively, with three arches of 20 feet span each, at either end forming abutments; the total length is 810 feet, by 21 feet wide, and from the top of the parapet to the top of the foundation, at the point of the greatest depth, is 156 feet 6 inches. It is entirely constructed of freestone from the Pensher quarries adjoining; and as a plain, simple structure, containing boldness of design, with excellence of execution and economy, rivals any other work of the kind in Great Britain. The means employed by the contractors for executing the work, appear to have been very complete. The north arch, of 100 feet span, containing about 980 tons of stone, was entirely turned in twenty-eight hours by two of the cranes employed in laying the stones, giving an average weight of 17½ tons of stone laid by each crane per hour. The bridge was commenced in 1836, and finished in 1838, occupying 714 working days, and cost about 35,000*l.*—*Inst. Civ. En.*

Mining Journal.

Experiments on Locomotives.

Experiments on the Grand Junction Line, with six-wheel Engines.

Name of engine.		Gross load. Tons.	Mean speed in miles per hour.	Coke consumed. Per mile in lbs.	Coke consumed. Per ton per mile.
Phalaris,	May 30 31 June 1 July 5	59.2	23.05	37.03	.62
Prometheus,	June 5 " 6 " 7 " 8	56.7	22.53	34.3	.60
Prometheus,	June 11 " 12 " 13	52.8	22.30	41.9	.79
Phalaris,	June 14 " 15 " 16	62.6	22.08	38.5	.61

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Experiments on the London and Birmingham Line, with Bury's four-wheel Engines.

Description of engines.	Gross load in tons.	Mean rate of speed in miles per hour.	Coke per ton per mile.
12-inch cylinders and 5-feet wheels,	50.15	30.51	.47
	70.95	28.53	.4
	81.61	21.85	.35
12-inch cylinders and 5-feet wheels,	50.77	31.29	.55
	69.76	29.82	.41
	83.53	19.42	.29

Lond. Mech. Mag.

Engineering Science.

The tunnel on the line of the Sheffield and Manchester Railway will be three miles in length, upwards of 600 feet below the surface, or summit, of the hill at its greatest height, and in rock formation throughout its entire length. The works were projected and commenced upwards of two years ago, under the direction of Charles Vignoles, Esq. Five shafts were opened, at about half a mile distant from each other, for the purpose of proving the formation, of facilitating the driving of the drift-ways, and, ultimately, of ventilating the tunnel. Whilst these were in progress, the drift-ways were carried on from each side, or face, of the mountain; the distance, or length, driven, on the eastern side, extending to nearly 1000 yards, and from the next shaft 180 yards. The junction between these two portions of the drift-way was effected on the 17th of September, and the levels, when checked, on a tie-bench, at the point of meeting, had varied but nine decimals, or one inch nearly, and the range was within less than two inches of being geometrically true. When it is considered that this has been attained whilst driving upwards of half a mile through hard rock formation, it must be admitted to be highly creditable to the parties engaged in directing it.—*Dub. Ev. Post.*

Lond. Athenæum.

Practical & Theoretical Mechanics & Chemistry.

On the Properties of the Crank.

Till very lately, the contrivance of a mechanism which would generate power, was thought quite a legitimate problem. Government fostered this belief by a proclamation which it has not yet recalled, offering a tempting reward for its solution. The error has finally passed into the hands of a few wrong-headed individuals, ignorant alike of the history and of the principles of mechanics; but we have only passed from one extreme to the opposite. We rarely meet with candidates for the proffered reward which is so temptingly held out to the discoverer of the perpetual motion; but we are still infested by

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another fallacy, which, notwithstanding its opposite tendency, belongs to the same category. We are no longer told that mechanism *per se* can generate power; but the opposite opinion, that machines, independently of the friction of their rubbing parts, are capable of destroying power, has still numerous and intelligent adherents. Thus we are perpetually informed of the great and needless waste of power which results from obliquity of action in the moving parts of a machine, and are not unfrequently called upon to examine cumbrous and expensive contrivances for rendering these actions direct, and for recovering—it may be more than recovering—the power believed by the inventor to be unnecessarily thrown away.

From this to the conception of a perpetual motion, is only a step; for admitting a machine to be capable, independently of friction, of destroying power, we might rationally expect that the inverse action of the same machine would be capable of generating it. Both doctrines are equally inconsistent with the fundamental laws of mechanics, and with that law of mechanism which informs us that, in every combination of the ordinary mechanical powers, supposed to be divested of friction, the efficient power is of precisely the same value at all points, understanding the efficient power to be the force multiplied into the velocity.

To develope this principle more fully, it is necessary to refer to the law of *virtual velocities.* This law informs us that, if two weights balance each other when suspended from unequal arms of a lever, that they are to each other inversely as the lengths of these arms; and if the lever be made to vibrate on its fulcrum, the distances through which the weights move are directly as the lengths of the arms from which they are suspended; so that, if each weight be multiplied into the distance through which it moves, the two products are equal to each other. Thus the descent of 1 lb. through 10 inches would, for example, be accompanied by an ascent of 10 lbs. through 1 inch; so that whatever is gained or lost in intensity of pressure, is lost or gained in distance. The same law holds true of combinations of pulleys, and also of the inclined plane and bent lever, although its application to these cases is not so obvious. It is also true of any combination of these mechanical elements; for if, in any machine, we induce motion, it may be found that the force transmitted, combined with its velocity, is equal to the force applied, combined with the distance through which it has advanced. This is true, however ill-contrived, and however ill-constructed, the machine may be; it delivers over the whole, and exactly the whole, amount of force which put it in motion. Part of this force it expends in overcoming the friction of the rubbing surfaces, including the resistance of the air, and gives up the rest as effective power to accomplish the particular purpose for which the machine is intended.

If, then, this principle be correct, it follows that, in every machine composed of the ordinary mechanical powers, the quantity of power developed, that is, the dynamical effect of the moving force, is the same at all points, and that the power is transmitted without any other change in its value than is caused by the loss resulting from

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direct his attention only to two objects—economy in the material and labor necessary to the first construction of the machine, and the diminution, as far as practicable, of the effects of friction. Were all friction avoided, it would be matter of absolute indifference by what means the required changes of motion might be produced; it would then be of no moment whether we employed the reciprocating, or the rotary, steam engine—whether we adopted short, or long, connecting-rods—whether we used the crank, or the sun and planet wheels, further than the mere expense of workmanship is concerned. Beyond this, and the comparative amounts of friction, we have absolutely no criterion for estimating the superiority of one mode of construction over another.

It would not be difficult to establish the principle involved in these broad statements by general reasoning applicable to every possible combination of machinery; but we shall, in the mean time, confine our attention to the condition of the steam engine crank—the groundwork, at present, of much pernicious fallacy and needless controversy. This may seem inconsistent with the simplicity of the crank, for no machine can possibly be more elementary in its character, and, we might suppose, could be more easily understood, and give rise to fewer doubts respecting the nature of its action. So simple is it, that we can hardly reckon it an addition to the axle of which it forms a part; it is merely a *crook* upon it, and appears to have been the earliest contrivance for the purpose of converting a revolving into a rectilinear motion, and the reverse. It is figured in the old machines of the Egyptians, the Chinese, the Greeks, and the Romans; and it has been employed to move the pistons of the cylinders of water-pumps, since the time of Aliotti, in precisely the same way as it now moves in the steam engine. A radical misconception has, however, arisen regarding it, and a multiplicity of crude and abortive contrivances have been proposed to supersede its use—all less elementary in their character, and every way inferior in point of practical application.

To show the grounds upon which this misconception rests, it is observed that there are only two points in a revolution of the crank at which the connecting-rod (*supposed here to be infinitely long*) forms with it a right angle, and it is only at these points of full-leverage that the whole force of the steam transmitted through the rod is acting to produce effective motion of the crank. These positions are denoted by figs. 1 and 2. But, again, in the positions indicated by figs. 3 and 4, the connecting-rod and crank are in the same straight line—technically called the "position on the centre," or passing the "line of centres," and the "dead-power points"—in which the leverage of the crank is nothing, and, consequently, no power, however great, acting through the rod, could produce rotary motion in it, in either direction. The force at these two positions is exerted upon the crank-centre alone, whilst, at the points of greatest leverage, no part of it is thus exerted—the whole there tends to cause the crank to turn upon its centre. At all intermediate positions, the force transmitted through the rod is resolved into two effects—one acting to give the crank rev-

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olution, and another acting upon its centre; and it is further clear, that, the leverage of the crank increasing from zero to a maximum during the first quarter revolution, and diminishing from a maximum to zero during the next quarter, the efficiency of any force transferred to it through the connecting-rod will, in like manner, increase from zero to a maximum, and diminish from a maximum to zero.

Fig. 1.

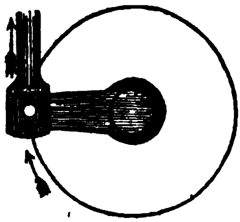


Fig. 2.

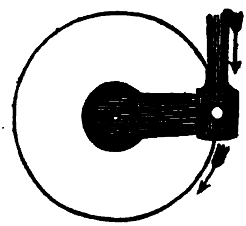


Fig. 3.

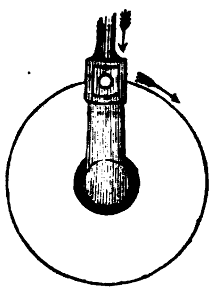
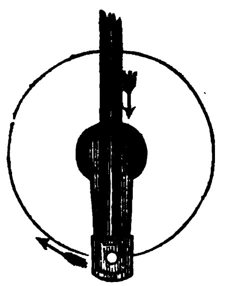


Fig. 4.



Were we, therefore, to stop short in our examination at this point, we might also conclude that the crank is a "losing lever," and set about equalizing this *apparently* most unequal action, and saving the power so prodigally thrown away in our steam engines. Another step in the analysis serves, however, to convince us that the pressure produced upon the crank-centre does not imply a loss of dynamical force; that when the apparent loss is greatest, there is no loss whatever; and that, at every point, the effect produced is in direct relation to the quantity of steam producing it.

To show how these conclusions are arrived at, let it be recollected that, at the two extremes of the line of centres—the neutral points—the greatest apparent loss takes place. A moment's reflection is, however, sufficient to convince us that, at these instants, there cannot possibly be any loss; there is no power expended, and, consequently, none wasted. The supply of steam, the element of power, is closed —the communication with the boiler is cut off—the steam in the cylinder has done its work, and only waits to be dismissed the instant

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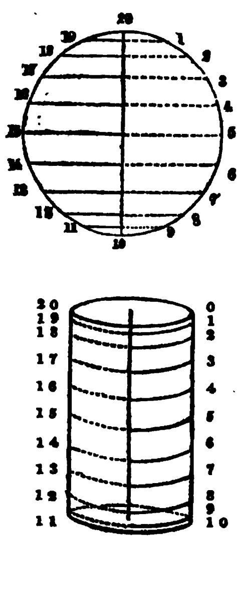
the eductive passage is thrown open for egress. Communication being opened with the boiler, the entering steam finds the piston almost in contact with the end of the cylinder at which it enters—it insinuates itself into the vacant disk—the piston yields to the pressure, and begins to move towards the opposite end of the cylinder. At first its progress is slow, but gradually accelerates, till, on reaching the middle of the cylinder, it moves with the full velocity of the crank in its circle. But, from the moment that it passes that point, that is, half way to the end of its course, the velocity of the piston begins to be retarded, and its final stoppage prepared for. At last, the rectilineal motion, having dwindled to nothing by insensible shades, altogether ceases. The expenditure of steam, mean time, corresponds to the motion of the piston—first, it expands, with a continually increasing movement, to the point of half-stroke, and then its expansion begins to diminish, till, finally, it ceases to produce any effect, and is released from its confinement by the opening of the eductive port.

Such is the history of the progress of the piston, from one end of its cylinder to the other. During the first half of its course, its motion is gradually accelerated by increasing increments; it then begins to be retarded, and is finally brought to rest by decrements of motion in the inverse order.

Our next business is to trace the simultaneous motion of the point which, by its connexion with the piston, is carried round the circumference of a circle, while its mover progresses in its reciprocal strokes in the cylinder, and to inquire how this gradual change from rest to motion, and from motion to rest, can be rendered consistent with the uniform motion of the crank in its circle. To facilitate this part of the inquiry, and show the relation which these motions bear to each other, it is necessary to have recourse to a simple diagram, such as that annexed, in which the circle represents the path of the crank, and the figure below it, the steam cylinder of corresponding length. The numerals on both figures represent the places of the crank and piston at given instants of time. The motion of the crank is supposed to be uniform, and, therefore, its orbit is supposed to be divided into twenty equal parts, the first ten numerals being placed on the descending, and the other ten on the ascending, side of the circle. The length of the stroke of the piston—which is equal to the diameter of the circle—is similarly divided into ten unequal parts, showing the places of the piston at those instants of its stroke which correspond with the contemporaneous points of the crank's orbit—the first ten numerals corresponding both in the circle and cylinder with corresponding points of reciprocation and revolution.

Fig. 5.



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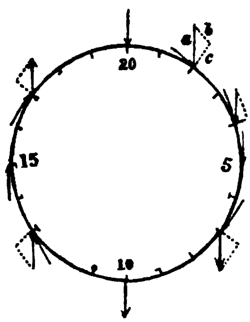
Now, in order to arrive at a proper estimate of the relation which exists between the pressure of the steam on the piston, and the quantity of effect produced in revolving the crank, and that part of the pressure of the steam which produces no motion, and which is therefore said to be lost,—let us construct such a diagram as that annexed of the crank's orbit; and let the arrows placed vertically denote the force of the steam transferred through the connecting-rod—those placed as tangents, the part of that force tending to produce revolution in the crank—and the lines directed to the centre, the apparent loss. Then, knowing the amount of steam pressure transferred, we can easily ascertain the relations of the lines *a*, *b*, and *c*, to one another, and, thereby, the force acting in the direction of the circle, and also that acting upon the centre of the crank at those points. Other figures, showing the relations of the forces, may, in like manner, be constructed at any of the other given points of the circle—the conditions of the construction being, simply, that *a* represent, in magnitude and direction, the force transferred through the connecting-rod; that *b* be parallel to the direction of the circumference (or tangent) of the circle at that point, and that *c* be directed from the same point to the centre; and further, that *b* and *c* be produced till they meet, and thus determine each other's magnitude in relation to the constant quantity, *a*. Constructed upon a sufficiently large scale, the relation of the forces may be ascertained with sufficient accuracy by the compasses; and only a very slight knowledge of calculation is necessary to verify the results contained in the following table, which is calculated for all the points marked in fig. 5, upon the assumption that the force of the steam $a = 100$ lbs.



Points in fig. 5.	Area moved over by the crank.	Force in the direction of revolution: Value of *b*.	Pressure upon the centre: Value of *c*.	Relative velocity of crank to piston.
20	0°	0.00	100.00	Infinite.
1 and 19	18°	30.90	69.10	3.236
2 " 18	36°	58.78	41.22	1.701
3 " 17	54°	80.90	19.10	1.236
4 " 16	72°	95.11	4.89	1.051
5 " 15	90°	100.00	0.00	1.000
6 " 14	108°	95.11	4.89	1.051
7 " 13	126°	80.90	19.10	1.236
8 " 12	144°	58.78	41.22	1.701
9 " 11	162°	30.90	69.10	3.236
10	180°	Mean 63.138	Mean 36.862	Infinite.

According to this table, then, only about 63 per cent. of the steam

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force tends to produce motion in the direction of the centre. Now, it is this 37 per cent. (something more than one-third of the whole force) which is considered to be lost by the crank; and the reasoning which has led to that conclusion is in every way similar to that here adopted. But, without proceeding further, it might be suggested, that, as the centre of the crank is fixed, and prevented from yielding, except to the force acting to produce revolution, that no *power* can possibly be expended in this pressure; for no motion is produced towards the centre, but only in the direction of the circumference. That which we call *power* is not pressure, but pressure combined with motion. The ram of the pile-driving engine may be suspended by the shears for any length of time, without expenditure of force—it becomes no lighter by suspension, and not a whit less ready to fall, in obedience to the force of gravity, when it is released. Yet, if mere pressure be taken as power, that power ought constantly to become less and less by continuance of action; and not only the ram, but every body which presses upon the earth's surface, ought, according to this doctrine, to be giving out their *power;* and, applying the supposition to the case in hand, there must be an enormous waste of *power* constantly incurred in the steam engine, by the pressure of the steam upon the interior of the boiler in which it is generated.

It is to such absurdities as these that we are led by confounding pressure and power. We must, therefore, bear in mind, that, in all calculations respecting power, we must attend to the space passed over, as well as the force exerted in that space; and that a force of 1 lb., moving through ten inches, is equivalent in effect, as already stated, to a force of 10 lbs. moving through a space of one inch; that is, in calculating the quantity of effective power, a greater velocity is equivalent to a greater force. Applying this to the case in hand, let the connecting-rod and crank be so nearly in a line, that a pressure of 100 lbs. upon the piston exerts only a pressure of 1 lb. in the direction of rotation; then does it follow, that, if the piston advance minutely in the cylinder, the extremity of the crank will advance one hundred times as far along its path. The quantity of effective power developed is thus equal to the power expended; for the quantity of motion generated in the machine is precisely what is due to a pressure of 1 lb. acting through one hundred times the advance of the piston—or, what is the same thing, to the pressure of 100 lbs. acting through that advance itself. This is true of any other minute motion of the piston, and may be verified as nearly as the approximate results contained in the table given above will allow, for any part of the crank's revolution. Thus, by reference to the table, it will be observed, that, when the crank has advanced 18° in its orbit, the force of the connecting-rod, tending to produce revolution of the crank, is 30.9 lbs., and that the relative velocity of the crank is to that of the piston as 3.236 to 1. Now, supposing these relations to remain the same while the piston advances through one inch, then, the pressure being 100 lbs., the effective power of the piston is expressed by 100 lbs. $\times$ 1 =

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100 lbs.; and the pressure in the direction of the crank's orbit being 30.9 lbs., and the velocity 3.236 inches, the effective power is expressed by 30.9 lbs. × 3.236 = 99.99 lbs.; that is, 100 lbs. very nearly, the deficiency arising from the fractions of the factors 30.9 and 3.236 not being complete.

What is thus true of a minute portion of the stroke, holds equally true of it as a whole; for while the piston moves through the length of the cylinder, which is equal to the diameter of the crank circle, it moves the crank through one-half of a revolution. Now, the length of the diameter of a circle bears to the length of its semi-circumference the following relation—

Diameter : semi-circumference : : 2 : 3.14159,

that is, very nearly the ratio 63 : 100. In other words, if the length of the stroke be 63 inches, the space passed over by the crank in its orbit will be 100 inches. Now, the mean force on the crank, in the direction of revolution, is shown by the preceding table to be also 63 to 100, which shows that the mean force in the piston is greater than the mean force in the crank, in precisely the same ratio in which its velocity is less than the velocity of the crank. And, therefore, the effective power in the one is equal to the effective power in the other. To render this, if possible, more clear—the pressures on the piston and crank being inversely as the spaces through which they move, and the motive force in the cylinder being 100 lbs., moved through a space of 63 inches, (the length of the stroke,) we have, as the effective power of the piston, 100 lbs. × 63 = 6300 lbs.; and, for the motive power given out in the crank, 63 lbs., moved through a half revolution of 100 inches, that is, 63 lbs. × 100 = 6300 lbs.

The conclusion, then, that the power of steam is by no means disadvantageously applied through the crank in the ordinary way, rests upon these facts:—1. The velocity of the crank in its circle is in the inverse ratio of the pressure upon it. 2. The mean pressure on the crank during the whole revolution is less than the pressure on the piston, in exactly the same proportion that the space moved over by the latter is less than the space described by the former, so that the whole effect is equal to the whole power. 3. The steam is not at all expended at the neutral points, and its expenditure at every other point is exactly proportioned to the pressure it gives out in useful effect. 4. The velocity of the piston is the ratio of the force acting at each instant on the crank to produce revolution. Making, therefore, allowance for friction, we may rest satisfied that we receive through the crank, in actual work done, all the power of the steam applied to it in the cylinder—and that no force whatever is lost by obliquity in action.

This is, indeed, proved in the most satisfactory manner by the practical fact, that the crank engines of Cornwall are in every respect as effective, and do as much work, as the average of those which have no crank. And it may be worthy of remark, that, as far back as 1837, it was proved in the most careful way, by Mr. Smith, of Manchester, that the work done by the crank engines of Charleston and

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Wheal Kitty, constructed by Mr. Sims, was within ten per cent. of the power employed—a fact which, of itself, would seem enough to induce contrivers of crank substitutes to reconsider the question.

As a means of converting the reciprocation of the piston of a steam engine into continuous revolving movement, the crank possesses some singular and beautiful properties, which distinguish it from every other mode of producing that conversion, and which appear to be so perfectly adapted to the nature of steam, and the constitution of solid matter, that we are indebted to it materially, although indirectly, for the very great advantages we derive from the modern steam engine as a source of mechanical power. Ingenuity has been taxed to the utmost to find substitutes for it, which should remedy its imaginary defects; but, after many vain efforts, it is found that the crank is the magic rod through which the mighty force of the element can be transmitted peaceful and docile. It may be said, that successful substitutes have been contrived, and the beautiful sun and planet motion of Watt may be cited in evidence; but only a very slight examination of the contrivance is necessary to show that the crank, though disguised, was present, and that the success depended upon its presence. It was not a want of confidence in the crank which produced the sun and planet motion; it owed its contrivance simply to an invidious patent, and, as soon as that patent expired, the disguise disappeared, and the simple unincumbered crank assumed its place.

To see in what its superiority consists, let it be observed that, in the reciprocating piston, the following things take place: The piston is to be put in motion in one direction, then stopped; then put in motion in the opposite direction, stopped again; motion in the first direction begun, and once more made to cease. But these processes which produce the change of state from rest to motion, and from motion to rest, require time. Matter in motion acquires momentum, which must be gradually removed, otherwise these moving parts are subjected to concussion, as by the stroke of a hammer, and either suffers, or produces, injury. On the other hand, when brought to rest, matter cannot be instantly set in motion in the opposite direction, without a stroke and concussion equally violent. These effects, therefore, cannot be instantaneous; yet it is necessary that the motion which the steam gives off should be converted into continuous and uniform motion, while the parts of the engine itself must be allowed time to be brought to rest without shock, concussion, or jolt, and gradually and gently be again urged to their greatest velocity in the opposite direction. All this the crank effects with the utmost nicety of adjustment: it stops the piston as gently and softly as if a cushion of eider-down were placed to receive it; and after having brought it to rest, as gradually begins and accelerates its motion to its highest velocity in the opposite direction. An adjustment so complete is only possible in such a relation as that which subsists between the crank and the piston: the one describing uniformly the circumference of a circle, while the other moves by simultaneous graduations of alternately increasing and diminishing extent.

Now, comparing this mode of action with that of any of the sub

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stitutes for the crank, by which it has been proposed to gain uniformity of power, we shall find that in these it would be required that the transitions from rest to motion, and from motion to rest, should be instantaneous, and hence such arrangements being soon disordered, have been speedily abandoned.

Perhaps one of the highest recommendations of a piece of mechanism is, that any very slight error in its construction shall not very materially affect its usefulness, nor any very slight derangement of its adjustment be attended with immediate deterioration; but that, on the other hand, the efficiency of the machine shall be consistent with such degrees of correctness of workmanship as can easily be accomplished, and such attention in superintendence as can readily be obtained; also, that the progress of disrepair shall be so gradual as to give timely warning of danger, and admit of ready repair and re-adjustment. The crank is precisely such a piece of mechanism; it possesses the property of reducing the errors of construction, arrangement, management, and adjustment, in a remarkable degree. This is well shown in respect to the valves. It is at the top and bottom of the stroke that the opening and shutting of these take place, and it is at these points that a minimum of the pressure on the piston is transferred to the crank, so that if the valves do not open with perfect precision, but either a little too late, or too soon, then will such error at that part of the circuit be comparatively harmless, for just then the motion of the piston is so slight that, through an arc of twenty degrees of the crank's orbit, it does not advance the hundredth part of the stroke, and therefore the effect of any error contained within that range will not affect the result of the crank by one-hundredth part of its full amount. Any error of adjustment is therefore diminished in effect to one-hundredth part of what would be produced, were the motion of the piston to be uniform, in portions corresponding to the arcs described, as would be the case in any other species of rotary conversion.

To this enumeration we might add other properties, but, perhaps enough has been said to remove the fallacy which would convert the simple crank into a destroyer of power. If so, our object is attained, and we shall be glad to find that the ingenuity and perseverance hitherto expended upon substitutes for the crank, are directed to more useful and rational purposes. A sufficiently wide field is open to improvement in the mechanical arts without interfering with a mechanism, which we have no hesitation in saying, is as perfect and simple in its nature as human ingenuity can make it.

Observations on M. Reiset's Remarks on the new method for the Estimation of Nitrogen in Organic Compounds, and also on the supposed part which the Nitrogen of the Atmosphere plays in the formation of Ammonia. By H. Will, *Ph. D.**

The method for the estimation of the nitrogen in organic substances

* Read before the Chemical Society, March 21, 1843.

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described by Varrentrapp and myself* has been received by many chemists with the greatest approbation, as well on account of its simplicity as the accuracy and security with which results can be obtained. M. Reiset has however presented an essay to the Academy of Sciences at Paris,† in which he endeavors to prove by experiments at first sight very convincing, that the above-mentioned method is attended by two sources of error; the first of which in particular, were it true, would be quite sufficient to destroy completely the value of the method.

The cause of this first and principal source of error is, according to M. Reiset, that the nitrogen of the atmosphere forms a portion of the ammonia produced by the decomposition of nitrogenous matter by means of an alkaline hydrate, and that consequently too large an amount of nitrogen must always be obtained, particularly in bodies rich in carbon, bodies of difficult combustion, and those which readily form cyanogen compounds. This source of error becomes the more important, as from the experiments of Faraday,‡ which are confirmed by Reiset, it appears that by the fusion of many non-nitrogenous bodies with the hydrates of the alkalies a pretty considerable quantity of ammonia is formed. To those non-nitrogenous bodies which produce ammonia belongs in particular sugar, a substance which we proposed as an addition for the purpose of diminishing the violence of the absorption of the ammonia by the hydrochloric acid.

The numerous analyses of nitrogenous bodies made by Varrentrapp and myself, must have given a very considerable excess of nitrogen, if any formation of ammonia really took place, and were a constant source of error: it would be particularly evident in the analyses of ammeline, in which we mixed the substance with an equal weight of sugar. The accuracy and strictness of the results obtained by us from substances of well-known composition could therefore be ascribed only to accident, or perhaps to some source of error balancing the one just mentioned.

We thought we had met every objection of a source of error on this point by the experiments mentioned in our paper, in which we passed nitrogen and hydrogen gases through a glass tube over a red-hot mixture of carbonized bitartrate of potash and lime, or of pure charcoal soda and lime, and from which we did not obtain sufficient ammonia to be estimated as ammonio-chloride of platinum; and yet all the conditions necessary for the formation of ammonia and cyanogen were afforded in the mixture of soda, lime and carbon by the hydrogen becoming free from the combustion of the carbon at the expense of the oxygen of the hydrated water, as well as through the difficulty of its combustion.

M. Reiset appears to have overlooked the fact that finely divided carbon is also, as well as an organic substance, oxidized completely by means of the hydrates of the alkalies, and states that we have

* *Annal. der Chemie*, b. xxxix, s. 257. See also Philos. Mag. for March 1842, p. 216.

† *Compt. Rend*, vol. xv, p. 154; and *Ann. de Chim. et de Physique*, 3rd ser. vol. v, p. 469.

‡ Quarterly Journal of Science, vol. xix, p. 16; and Poggendorff's *Annalen*, vol. iii, p 455. [Also Phil. Mag. S. 1, vol. lxv, p. 309.]

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neglected to prove in a satisfactory manner, that the facts observed by Faraday, according to which non-nitrogenous bodies, as sugar, acetate of potash, oxalate of lime, tartrate of lead, &c., by ignition with potash, soda, and hydrate of barytes, and access of air, give an appreciable quantity of ammonia, are without influence on the new process of analysis. He has undertaken this for us; and his experiments, which were made with stearine and sugar, gave him on combustion with soda-lime, under the same circumstances as in the execution of a nitrogen analysis, the following very remarkable results:—

Sugar.	Platinum obtained.	Nitrogen obtained.	Nitrogen in 100 parts.
0.250	0.02650	0.0038	1.52
0.500	0.05250	0.0075	1.50
1.000	0.0890	0.0127	1.27
1.500	0.104	0.0149	1.00
2.000	0.10725	0.0153	0.75

In these experiments the quantity of ammonia obtained was in exact proportion to the quantity of sugar employed, as far as *one* gramme; with *more* sugar, more ammonia was not obtained.

Reiset obtained further from 1 gramme stearine, 0.06475 platinum = 0.0092 nitrogen, and in two other experiments with sugar performed in an atmosphere of hydrogen (from 1 gramme,) 0.03375 and 0.034 platinum = 0.0048 nitrogen.

From both these last experiments, according to which non-nitrogenous bodies also eliminate ammonia in an atmosphere of hydrogen, M. Reiset concludes that the alkaline mixture possesses the property of condensing nitrogen so intimately and strongly that it cannot be expelled completely by a current of hydrogen passed over it for six hours, and that this state of condensation, approaching as it does the nascent state, makes the nitrogen more apt to enter into combination.

As a further proof of the incorrectness of our method, M. Reiset brings forward the analysis of cinchovatina, an organic base discovered by Manzini in Jaën Cinchona, from an analysis of which, performed with a mixture of sugar, almost 5 per cent. more of nitrogen than the calculation required was obtained. 0.052 cinchovatina gave, namely 0.949 ammonio-chloride of platinum = 11.95 per cent. nitrogen. The calculation from the formula $C_{46}H_{27}N_2O_8$ gives only 7.16 per cent.

The excess of 4.8 per cent. here obtained, estimated by weight, amounted to 0.024 gramme nitrogen, or in volume nearly 25 cubic centimetres; in the above experiments with sugar 0.015 gramme of nitrogen was, according to M. Reiset, condensed in the soda-lime, and therefore took a part in the formation of the ammonia.

If we consider that the decomposition of organic bodies of difficult combustion by the hydrates of the alkalies does not take place at a heat below redness, that further, the heating of the contents of the tube by the fire placed around it cannot be so sudden as to produce in an instant the temperature necessary for combustion, but that the heat, even when sudden, penetrates the mixture only by degrees, and that the greater portion of the inclosed or condensed air is driven out

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by its own expansion, we can scarcely comprehend how M. Reiset could entertain the idea that the nitrogen condensed in the mixture could take a part in the formation of ammonia. He certainly brings forward an experiment apparently supporting this view, viz. that by the combustion of 1.500 gramme of sugar in a current of air, the combustion being thus quickened, only 0.0099 nitrogen was obtained, instead of 0.0149. The ammonia did not increase when pure nitrogen was passed over the mixture during the combustion. I shall subsequently return to this point.

I have repeated and partly varied the experiments of Reiset, and have come to entirely different results.

1.214 sugar-candy of the shops by combustion with the usual mixture of soda-lime, which had not been previously ignited, gave on evaporation with chloride of platinum and ignition of the washed residue, 0.006 metallic platinum = 0.00086 nitrogen = 0.07 per cent. of the sugar burned.

0.386 pure stearic acid recrystalized from alcohol, gave 0.002 metallic platinum = 0.00028 nitrogen.

0.430 leguminous starch, prepared in the laboratory of Giessen, and purified with sulphuric acid, gave 0.005 metallic platinum equivalent to 0.0007 nitrogen.

A gramme of the above-mentioned starch was submitted to dry distillation. The product of distillation was mixed with hydrochloric acid, evaporated, the residue dissolved in water, mixed with chloride of platinum, and again evaporated. After treatment with alcohol and æther, a portion of ammonio-chloride of platinum remained, which ignited left 0.004 metallic platinum. The ammonia obtained by the combustion with soda-lime was thus, in part at least, contained in the starch, and was no product of the operation.

In both the following experiments, conducted exactly as an ordinary combustion, I employed soda-lime ignited just before its introduction into the tube.

1.000 gramme stearic acid decomposed with soda-lime in a tube 1½ foot long and half an inch wide, left, after evaporation to dryness with chloride of platinum and resolution in æther-alcohol, no visible trace of ammonio-chloride of platinum.

2.000 grammes pulverized metallic tin, after ignition with soda-lime and treatment of the residue after the evaporation of the hydrochloric acid with chloride of platinum, afforded an extremely small quantity of yellow powder, which possessed all the properties of ammonio-chloride of platinum.

In the following experiments, a stream either of atmospheric air or of nitrogen was passed through the tube during the successive oxidation of the substance, by means of an alkaline hydrate. Both the atmospheric air and the nitrogen were dried by means of sulphuric acid, which had been freed from nitric oxide by treating with sulphate of iron.

The volume of gas passed through was about from three to four thousand cubic centimetres, and the combustion throughout the whole length of the tube was so conducted, the experiment lasting from two

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to three hours, that the conditions necessary for the formation of ammonia were given at every moment.

4.000 grammes perfectly pure recrystalized sugar, ignited in a tube 2½ feet long, with a large mass of soda-lime in a current of air, gave no trace of ammonio-chloride of platinum.

20 grms. of common pulverized tin, oxidized in the same way with soda-lime, gave a quantity of yellow powder, too small to be weighed. The uninterrupted disengagement of hydrogen proved, however, that the tin was oxidized at the expense of the alkaline hydrate.

4.300 grammes of recrystalized sugar were introduced by degrees through the tubulure of a retort whose neck was obliquely turned up, and in which soda-lime was in a state of fusion. An aspirator was attached to the absorption apparatus connected with the retort, so that the gaseous product formed, following the current of air, should pass through the hydrochloric acid. Only an extremely small trace of ammonio-chloride of platinum was obtained. The same experiment repeated with tin, zinc, and pure metallic iron, always afforded ammonio-chloride of platinum, yet so slight a trace that in most cases it did not admit of being estimated.

When hydrate of potash was employed instead of hydrate of soda, I always obtained potassio-chloride of platinum, because, from the violent evolution of the hydrogen, portions of the alkali were driven over into the hydrochloric acid. In another experiment 20 grms. of metallic tin were melted with fresh fused hydrate of soda in a thin U-formed tube, so that, during the continuance of the experiment, a fresh quantity of air was always brought into contact with the nascent hydrogen; I obtained thus 0.008 ammonïo-chloride of platinum = 0.00057 nitrogen. In an experiment in which nitrogen was used instead of atmospheric air, a similar result was obtained, namely, 0.007 ammonio-chloride of platinum.

These experiments prove that the nitrogen of the atmosphere can in no way form ammonia with hydrogen in a nascent state. The extremely small quantities obtained in most cases, must, consequently, have some other source, which it is very difficult to avoid. This, however, may be attained by the following method:—

Hydrate of soda was melted in a silver crucible until it became liquid, and then mixed with a small quantity of pure iron, reduced from the oxide by means of hydrogen. This was readily oxidized with disengagement of hydrogen gas; it was then poured into a silver dish, previously warmed, and, after it had cooled, was broken into pieces, and introduced into a slightly curved tube of hard glass, half an inch in diameter, previously ignited; from 4 to 5 grammes of pure iron, reduced from the oxide by hydrogen, were then immediately added; the tube was heated by charcoal placed under it, and nitrogen, or atmospheric air, passed through it. On the first passage of the air, an extremely small quantity of ammonia was generally detected by means of dahlia-paper, or by a rod moistened with dilute hydrochloric acid; but this disengagement of ammonia was only observed for a short time, and always ceased before the evolution of the hydro-

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a state of fusion, until all the metal was oxidized. By carefully following this plan, I never obtained ammonio-chloride of platinum.

The same experiment was repeated, with a like result, with perfectly pure crystalized tin, as it is easily obtained when a polished rod of tin is suspended in a vessel in which water, with a little hydrochloric acid, rests on a concentrated solution of tin; after one or two days, a splendid crystalization forms. If the metal happened to be touched by the fingers, or allowed to remain exposed to the air before the experiment, a disengagement of ammonia invariably occurred; but not when it, as well as the alkaline hydrate, were fused just before being employed. Pure tin is with great difficulty oxidized by hydrate of soda, and must be kept in a state of fusion with it for many hours before the oxidation is complete.

Reiset states that ammonia is disengaged by heating metallic iron and potash-ley to 292° Fahr., with access of air, but not so in an atmosphere of nitrogen. This statement rests on a very equivocal foundation. Pure iron can be heated for a long time in a boiling potash-ley without the disengagement of hydrogen; the oxidation takes place only on the fusion of the alkaline hydrates. If a quantity of potash-ley, which has stood for a long time in a perfectly clean retort, be heated, there is always observed, at the commencement, a slight disengagement of ammonia, but this soon ceases altogether.

The, by no means inconsiderable, quantities of ammonia obtained by Reiset, admit of no other explanation, than that his mixture of soda and lime contained a nitrate, probably nitrate of potash, which, as Faraday states, easily evolves ammonia when the smallest trace of it is melted with zinc and an alkaline hydrate. If Reiset had only, in a small degree, followed or observed the extremely cautious and circumspect manner of proceeding of that celebrated English philosopher—a manner which is with justice admired by him—he would not have endeavored to find sources of error in a method to which, on this point at least, no very weighty objection can be made.

The nitrate of potash contained in the soda-lime used by Reiset, was very probably owing to the circumstance that most manufacturers add a little of it to the commercial hydrates of soda and potash, for the purpose of improving their appearance. In Reiset's experiment, where he obtained 4.8 per cent. too much nitrogen in chincovatina, his mixture must have contained very nearly ½ per cent. of nitrate of potash, when it is considered that his tube contained from 50 to 60 grammes. This also explains, in a much simpler and easier manner, the formation of ammonia in an atmosphere of hydrogen, and also the limited increase of ammonia from the increased quantities of sugar employed. As the whole quantity of nitrate of potash would be destroyed by from 1 to 1½ gramme of sugar, the quantity of ammonia could not increase. The nitrogen was here certainly contained in such a condensed state, that a stream of hydrogen gas, passed over it during twelve hours, did not expel it.

I now come to the second source of error objected, by M. Reiset,

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to the new method. It appears, from his statements, that a part of the chloride of platinum is reduced to protochloride when the hydrochloric acid fluid, which in many cases contains liquid hydro-carburets, is evaporated to dryness with it in a water-bath; consequently, too much nitrogen must always be obtained, as this protochloride of platinum is insoluble in æther and alcohol. And this source of error has the more injurious effects on the result, the more its necessary conditions are afforded; and these conditions are the blackening of the hydro-carburets by the hydrochloric acid. In a direct experiment with sugar, made for this purpose, and in which the burning was managed in such a manner that the hydro-carburets, being produced at a low temperature, floated in abundance on the hydrochloric acid, on evaporation in a water-bath no reduction of the chloride of platinum could be observed. It must be allowed that, in such a trifling case of occurrence, the result would not be affected by it. Indeed, the formation of hydro-carburets, easily decomposable by hydrochloric acid, may be completely avoided by keeping the nearer end of the tube pretty strongly ignited, as the hydro-carburets are the more constant when produced at high temperatures.

The highly remarkable and accurate experiments of Faraday on the disengagement, or formation, of ammonia by the fusion of hydrate of potash with a metallic, or a non-nitrogenous, body, a result which I have also found in all my experiments, (but which was so trifling that it could not be attributed to any part played by the nitrogen of the atmosphere,) as also the investigation of Professor Liebig on the ammonia contained in rain-water, gives a complete and simple solution of the question, from whence comes this disengagement of ammonia, so often observed, and so difficult to be avoided?

The experiments of Faraday go entirely to show that there is some unknown source of ammonia, and that the nitrogen of the atmosphere in his experiments played no actual part; they are so convincing, and made without any preconceived opinion, that I cannot refrain from giving a short extract from them here. They prove, as it appears to me, directly the reverse to the conclusion which M. Reiset has drawn from them, and are of the greatest importance in the question, whether the nitrogen of the atmosphere plays a temporary part in the formation of ammonia by the decay of organic matter, or by the oxidation of metals, with or without the disengagement of hydrogen? An affirmative or negative to this question has a very important influence on the theory of the nutrition of plants.

Faraday observed that an organic substance, the quantity of whose nitrogen he wished to estimate, yielded ammonia by fusion with hydrate of potash, although he obtained none when it was heated alone in a tube. By extending his experiments further, he found that many non-nitrogenous organic bodies, as also many metals, presented this phenomenon, as, for instance, iron, zinc, tin, lead, arsenic, and also copper. He obtained, for example, a very perceptible quantity of ammonia with woody fibre, oxalate of potash, oxalate of lime, tartrate of lead, acetate of lime and asphaltum; with acetate of potash, acetate and tartrate of lead, tartrate and benzoate of potash, oxalate

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of lead, sugar, wax, olive oil, and napthaline, very little; and with resin, alcohol, æther, and olefiant gas, none whatever. The quantity of ammonia agreed, in a remarkable manner, with the quantity of hydrate of potash used in the experiment. He further observed, that perfectly pure hydrate of potash, evaporated so far that it ceased to give off water, when heated alone yielded no ammonia, but that it acquired this property when exposed to the air for some time. He observed exactly the same with caustic lime, and hydrate of lime, and also with fresh prepared potash-ley, allowed to stand for twenty-four hours.

Faraday further obtained ammonia when he heated a strip of well purified zinc with hydrate of potash, made from potassium, in a carefully prepared atmosphere of hydrogen; but could discover no ammonia when he heated the zinc with hydrate of potash which had been previously kept in a state of fusion until it ceased to give off water. He states, moreover, that the ammonia was generally observed before the disengagement of the hydrogen, by the decomposition of the substance employed, commenced.

Tartrate of lead, ignited with potash and the cold residue, brought in contact with a drop of water, evolved ammonia.

White clay from Cornwall, which, after being strongly ignited, was exposed to the air for eight days, yielded much ammonia; while another exactly similar portion of the same clay, which, after ignition, was preserved in a well-stoppered bottle, gave no ammonia.

Pure sea sand, heated to bright redness in a crucible, and cooled on a plate of copper, gave no trace of ammonia, although it was very readily observed when the hot sand, previous to its being heated, was held for some moments in the hand, and stirred about with the finger.

These experiments evidently agree with the observations of Braconnot,* who states that many porous minerals, such as trap from Chaume de Tendon, eurite, some species of granite, serpentine from the Vosges, ámphibole, muschelkalk, &c., by distillation in a glass retort, yielded an ammoniacal product.

The experiments of Faraday show with the greatest accuracy that the ammonia was not only not formed, but that it either existed already in the material employed, or received it from the air by exposure. The quantities obtained were so extremely small that he could not estimate them.

In the foregoing experiments, I have not only confirmed, but, at the same time, demonstrated the correctness of, Faraday's statement, that the nitrogen of the atmosphere does not in any way possess the property of forming ammonia with hydrogen at the moment of its separation from any combination. If this were the case, a quantity of ammonia capable of being estimated, and in proportion to the duration of the experiment, or the quantity of the material, would have been obtained in the experiments with tin, iron, and sugar—in which, by the gradual heating of the substance with an alkali in a continued

* Annales de Chimie et de Physique, t. lxvii, p. 104.

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current of air, or of nitrogen, the conditions for the formation of ammonia were as favorable as possible throughout the whole combustion; but this did not occur, and, by proper care, we are even in a condition to avoid every trace of ammonia, although nascent hydrogen may come in contact with nitrogen gas.

If we consider that ammonia forms a never-failing constituent of our atmosphere—that, further, it is a body which is easily absorbed by liquid and porous substances, particularly when these latter possess, at the same time, the properties of an acid,—we must at once perceive that, being in possession of an exceedingly delicate test of the presence of ammonia, that volatile alkali must be found in all, or nearly all, substances exposed to the air.

It is quite evident from this why Faraday did not obtain ammonia with fresh hydrate of potash which had been previously melted, nor with resin, which is not a porous body, although resin, like other organic bodies, was decomposed with the disengagement of hydrogen gas by fusion with the hydrate. A small quantity of nitrogen, contained in the body as a constituent, may be in part, or altogether, the cause of the disengagement of ammonia in many cases where Faraday observed it. The fact that the flocculent black residue, always obtained by the solution of zinc in sulphuric acid, after being well washed, disengages a pretty considerable quantity of ammonia, accounts very easily for the presence of nitrogen in commercial zinc. Cast iron, according to Schafhaeutl, also contains nitrogen.

The statements contained in most treatises on chemistry, that iron, by its change into oxide, under the combined influence of moisture, and air containing carbonic acid, affords the nitrogen of the latter the conditions necessary to form ammonia, agree exactly with the above cases of its supposed formation. This production of ammonia, if it actually took place, presupposes that iron is capable of decomposing water, with the disengagement of hydrogen gas, at the common temperatures, which is by no means the case; it presupposes further, that the hydrogen, on being set free, possesses a far greater affinity for the nitrogen, than for the oxygen, of the atmosphere, which completely contradicts our general experience. At high temperatures, where water would be decomposed by iron, ammonia is not formed. Kuhlman* obtained only hydrogen and nitrogen, but no ammonia, by the passage of steam and nitrogen over pyrophorous iron heated to a strong red heat.

I have repeated the doubtful experiment of Austin, (at least according to the result of Hall,†) in such a manner that the ammonia in the atmosphere (but not its carbonic acid) was, as perfectly as possible, shut out. I introduced into a flask, of from four to five litres capacity, some iron nails, (one pound,) previously cleaned from all oxide by dilute hydrochloric acid, and then well washed with pure water, and also sufficient distilled water to cover the bottom. The flask was connected, air-tight, by an intermediate tube, with a second smaller

* Abhandlung ueber die Saltpeterbildung: Annal. der Chem. und Pharm., Bd. xxix, S. 285.

† Ann. de Chim. et de Phys., t. ii, p. 42.

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one, which contained a small quantity of very dilute muriatic acid. By a second hole bored in the cork of the small flask, a tube containing asbestos, moistened with pure sulphuric acid, was attached, and through which the external air communicated with that contained in the greater flask. The object of the hydrochloric acid was to prevent the ammonia formed from passing into the sulphuric acid. The air was renewed every day in such a manner, through a second tube, closed with wax, in the cork of the first flask, that the air entering must pass through the sulphuric acid tube.

After from fourteen to eighteen days' oxidation, the oxide, of which a considerable quantity had already formed, was washed out of the flask with water and a little dilute hydrochloric acid; dissolved in hydrochloric acid, and the solution, to which chloride of platinum was added, evaporated nearly to dryness in a water-bath. The residue dissolved completely in æther-alcohol, and did not deposit a trace of ammonio-chloride of platinum even after standing for twelve hours, nor could any ammonia be found in the muriatic acid contained in the small flask. If the iron was here oxidized at the expense of the water, and if the hydrogen by that means set free had, at the moment of its disengagement, formed ammonia with the nitrogen of the air, nearly three grammes of ammonio-chloride of platinum would have been obtained for every gramme of the oxide treated in the above manner. This is a quantity which could not escape observation.

There is no doubt from this that the ammonia observed in the rust of iron was obtained from the atmosphere.

Herman,* in an essay "On the decay of wood," mentions an experiment in which the nitrogen of the atmosphere was directly absorbed, and partially converted into ammonia, by the decay of fresh wood. Herman found nearly one-third part of the nitrogen, which, according to his experiments, existed as a constituent of the wood, in the products of its decay. He concludes from this that two parts escaped in the form of ammonia.

The most perfect process of decay with which we are acquainted, is the production of acetic acid from alcohol. If the nitrogen of the atmosphere possessed the property of taking part in these metamorphoses, instead of pure acetic acid, an ammoniacal salt of it would be obtained in the quick process for the manufacture of vinegar, where the woody fibre undergoes a slow decay with the alcohol. As yet, however, no ammonia formation has been observed.

The process of decay of organic substances which contain little, or no, nitrogen at the surface of our planet, is as old as the occurrence of living matter upon it; it is so general and everywhere perceptible, that our atmosphere would soon be poisoned with ammonia, there being no such chemical attractions for *nitrogen* gas (as an element) as for oxygen; and its amount of nitrogen would certainly have decreased, if this most indifferent of all gaseous elements possessed the property of contributing, as such, to the formation of ammonia.

Lond. & Edinb. Philos. Mag.

* Journ. für Prakt. Chemie, Bd. xxvii, S. 165.

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On a new Method of obtaining pure Silver, either in the metallic state, or in the form of Oxide. By WILLIAM GREGORY, M.D., F. R.S.E., Member of the Chemical Society, &c.

The chemist, as well as the metallurgist, has frequent occasion to purify silver, especially from copper, which is dissolved along with it by nitric acid, the proper solvent of silver. By converting the silver into the insoluble chloride, it is effectually purified from copper, as well as from all other metals, the chlorides of which are soluble. But here the difficulty begins: the chloride of silver is a very unmanageable product, at least in the moist way. It is true, that, if placed in water acidulated with hydrochloric acid, in contact with zinc, or iron, the chloride of silver is reduced. But the process is tedious, seldom complete, and, in the end, unsatisfactory; for some zinc adheres to the reduced silver, so that it is not removed by digestion with moderately strong hydrochloric acid. This is proved by the action of am monia, which extracts a good deal of oxide of zinc. Moreover, the zinc, or iron, is hardly ever pure; and its impurities, arsenic, carbon, and perhaps also copper and tin, remain with the silver. I have never got from silver, thus reduced, a colorless solution of nitrate.

It is no doubt better to decompose the dried chloride of silver by the action of carbonate of potash, or soda, at a red heat. But, although the silver is thus obtained pure, the process requires much experience and dexterity. If the heat is too low, the reduced silver is disseminated in small globules through the mass; if too high, the alkali corrodes the crucible rapidly, and the contents fall into the fire-place, or ash-pit. There is often, also, a portion of silver cast up by the effervescence on the sides of the crucible, in small globules, which do not readily run down into the fused mass below. In short, this process, always ticklish, often fails. It is therefore desirable, if possible, to dispense with a furnace heat.

The method of reducing the silver from the impure nitrate by protosulphate of iron, does not answer. It is long ere the action is terminated, and, besides, some sulphate is always formed, which *is not reduced*, and is partly precipitated with the metal, and partly retained in solution.

The only remaining method, known to me, is that of reducing the silver from the impure (cupreous) nitrate, or sulphate, by means of copper. The chief objection to this method is, that it is somewhat tedious; but it is also not improbable, that a trace of copper may adhere to the silver, chemically combined, as is the case, to a large extent, with mercury in the *Arbor Dianæ*. At least, I have generally found copper in the silver I have thus prepared.

Considering these things, it appeared desirable to have, once more, recourse to the chloride, which can be easily obtained perfectly pure, and to decompose it without the contact of any reguline metal. The most obvious plan was to try the action of caustic alkalies in the moist way, and, although it has been, singularly enough, hitherto overlooked, I find that caustic potash may be used with complete success.

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the reaction about to be described has not been noticed. But a solution of potash, spec. grav. 1.25 to 1.30, with the aid of heat, decomposes almost instantaneously the moist chloride of silver, converting it into a heavy, fine, jet-black powder, which is pure oxide of silver. This oxide dissolves without the smallest residue, and without effervescence, in diluted nitric acid, and yields a colorless and pure nitrate. The heat of the spirit-lamp reduces the oxide to a coherent, spongy, mass of absolutely pure silver.

The following method appears to me the most advantageous:

The cupreous solution of silver is precipitated by common salt, while hot, and the chloride of silver well washed by decantation with hot water. It should also be broken down with a spatula of platinum, or a glass rod, during the washing, but not ground in a mortar, which causes it to cake, and impedes the action of the potash. The chloride, *while still moist*, is covered to about half an inch with a solution of caustic potash, spec. grav. 1.25 at least, and then boiled. During the boiling, which is best performed in a capsule of clean iron, silver, or platinum, the chloride is to be well stirred, in order to bruise all curdy, or lumpy, particles. In five or ten minutes the powder has become black. If a small portion, taken out and washed, do not dissolve without residue in dilute nitric acid, the potash is to be decanted off, and the powder, still moist, is to be well rubbed down in a mortar, which may *now* bé done with advantage. It is then returned into the capsule, and again boiled for five minutes with the same, or with fresh, potash. It will now dissolve entirely in nitric acid; but, if not, a second grinding will infallibly succeed. It is now only necessary to wash the oxide, which is completed by decantation in a few minutes, as the powder, from its great density, sinks at once to the bottom. The first two or three washings are made with hot water, the remainder with cold water; for, when the oxide is nearly washed, it rises partially to the surface *with hot water*, and thus a loss is occasioned in decanting. Of course, the whole washings (except the first, owing to the strength of the potash,) may be conducted on a filter. But the powder is so fine, that probably a good deal would adhere to the paper when dry.

This oxide of silver appears in a form quite distinct from that of the oxide precipitated by potash from the nitrates, and is hitherto undescribed. It is very dense, homogeneous, and has a pure black color, which has, if anything, a tint of blue; whereas the common oxide is bulky, far less dense, and of a grayish-brown color. They appear, however, to be chemically identical. Not having a microscope, I have not studied their physical characters minutely; but I suspect, from its aspect in the liquid in which it is formed, that the new oxide is crystaline.

It is obvious that the above process furnishes an easy method of procuring a very pure oxide of silver, and, of course, the action of heat gives us the silver in the state of metal. It is, I conceive, applicable both to the manufacture of nitrate, (in a state of absolute pu-

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rity,) and to the metallurgic process for obtaining pure silver. For both objects, it is a matter of no consequence if some chloride should have escaped the action of the alkali. This chloride is left undissolved by the nitric acid, and is separated by filtration; while, if the oxide (not quite free from chloride) be mixed with a little nitre, or carbonate of potash, and fused, the whole silver is obtained with the utmost facility.* In order to give an idea of the ease with which the whole is performed, I may mention that I dissolved a half-crown, and obtained the whole of the silver it contained, within a very trifling fraction, (chiefly decanted in the *first* washing of the chloride, *but not lost*,) by the above process, *within two hours*, in a fused state. The silver was quite pure. There is no doubt that to chemists, also, an easy method of obtaining quickly pure oxide of silver, in a form much less hygrometric than the usual one, will be acceptable.

It is particularly to be noticed, that, if the chloride have ONCE BEEN DRIED, it is with great difficulty decomposed, even by a long boiling with potash.

King's College, Aberdeen, Jan. 20, 1843. Ibid.

The Hot Blast Patent.

In the House of Lords, on Monday, March 6th, before the Lord Chancellor, and Lords Brougham and Campbell, the case of the "Househill Coal and Mining Company *vs.* Neilson and others," came up for decision.

The appellants in this case were the defendants in an action tried before the Court of Session in Scotland, for an alleged infringement by them of the hot blast patent, when a verdict was found against them; and came now before the House of Lords on a bill of exceptions, tendered by them against the charge of the learned judge, (Lord Justice Clerk,) who presided at the trial.

The Lord Chancellor. My lords, the principal question in this case arises out of the eleventh exception. The learned judge (who presided on the trial) stated to the jury what he considered to be sufficient evidence to support prior use, so as to invalidate the patent. The learned judge expressed himself in these terms. He says: "You will observe that it is settled that the trials founded on as a proof of prior use, must have been public—must have been continued, not abandoned—must have continued to the time when the patent was granted—I do not say to the very exact period, but it must have been known and used as a useful thing at the time." (After some observations on the meaning of the word "trials" as used by the presiding judge in the jury court, the Lord Chancellor continued—I understand the proposition of the learned judge to be this—that if the machine had been made, and had been put in trial, unless those trials had gone

* In fact, this process, imperfectly performed, is an excellent preliminary step, when a large quantity of chloride is to be reduced. The impure oxide requires so little alkali to complete its decomposition, that the crucible runs no risk. A little borax may be added as a flux.

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on, and the machines had been used, up to the time of the granting of the letters patent, it would not be evidence of prior use so as to invalidate the letters patent. Now, I am obliged to say, with all deference to the learned judge, and with all respect to the learned judges of the Court of Session, that I think in that respect they are mistaken, and that, if it is proved distinctly that a machine of the same kind was in existence, and was in public use; that is, if use, or if trials, had been made of it in the eye, and in the presence, of the public, it is not necessary that it should come down to the time when the patent was granted. If it was discontinued, still that is sufficient evidence in support of the prior use, so as to invalidate the letters patent. If it is discontinued, provided it has been once in public use, and the recollection of it has not been altogether lost—if it has been once publicly used, it will be sufficient to invalidate the letters patent, although the use may be discontinued at the time when the patent was granted. Now, my lords, I apprehend that that is the law, and the known law, upon the subject in this country. I never heard it before questioned that the notorious public use of the invention, before the granting of letters patent, though it may have been discontinued, is sufficient to invalidate the letters patent. Then, my lords, the remaining question for consideration is this, and it is an important one, whether, if the learned judge laid down the law incorrectly to the jury, this was calculated to mislead the jury? (His lordship then explains how it was calculated to mislead, and says)—Therefore, it is perfectly obvious, that, if the learned judge be incorrect in the manner in which he stated the law, in the particular in which I have stated, it was calculated to mislead the jury. Under these circumstances, my lords, I should recommend your lordships to allow the eleventh exception, and to disallow all the rest.

Lord Brougham. My lords, I entirely agree in the view taken, and for the reason so luminously expressed, by my noble and learned friend on the woolsack. If we are of opinion, first, that the law has been mistaken, and, under a misapprehension of it, it has been erroneously delivered by the judge to the jury; and if we are, secondly, of opinion that the misdirection in point of law, the mistake in point of law, committed by the learned judge, had a direct tendency, I may almost say an inevitable tendency, to mislead the jury in the conclusion to which they should come, and in the verdict which they should render; then, my lords, both of these questions being answered in the affirmative, that the law was mistaken, and that the mistake tended to mislead the jury in their verdict, we have no choice, but must allow the exception. Now, my lords, a more important mistake in point of law, your lordships will give me leave to say, could not possibly have been made by the learned judge, than that into which the learned judge fell upon the present occasion. And I will not allow it to be said for one moment, in dealing with this question, that there is anything doubtful, that there is anything speculative, that there is any new law to be laid down, or even any new topics in respect of the law about to be broached here, in dealing with the direction of the learned judge; for I speak with all possible respect for that learn-

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ed judge's great ability and experience in his profession in Scotland, when I say that this law, which has been mistaken here by his lordship, is a matter of as perfect certainty, as thoroughly known, and as little drawn into doubt, in Westminster Hall, where the law is administered touching the construction of the statute of James, the Patent Act, as any one branch of the law most commonly known, and most frequently administered, by our courts. It is one of the greatest errors that can be committed, in point of law, to say that, with respect to such an invention as that, it signifies one rush whether it was completely abandoned, or whether it was continued to be used down to the very date of the test of the patent, provided it was invented and publicly used at the time, twenty or thirty, or as, in this case, forty, years ago, it is perfectly immaterial; there being, in my apprehension, no kind of doubt that the jury would say—"Why should we consider whether it was used at the Bradley Works, or not? Why should we consider whether it was a trial, or a completed invention? Be it so that it was used forty years ago—be it so that it was a complete invention; we hear the learned Lord Justice Clerk telling us that we need not trouble ourselves upon these facts, for it is enough for us if it was abandoned, and that takes the facts out of the case, and leads us to find a verdict the other way." Upon these grounds, my lords, we have no choice in this application, it being a bill of exceptions; we have no hesitation in saying that the law was misconceived, and misstated to the jury. The law is undeniable, it is a matter of no doubt or hesitation with any man in this country who has been accustomed to administer it, or, I will venture to say, with any practitioner whose opinion is entitled to any weight; and I am also of opinion that the law so laid down tended to mislead, and must necessarily have tended to mislead, the jury. Upon these grounds, I have no hesitation in supporting the proposition of my noble and learned friend, that the eleventh exception must be allowed.

Lord Campbell. The only question is this, whether this misdirection shall be considered as immaterial? When I look at the form of the issue, I cannot say that it was immaterial, because the issue is, "whether the invention, as described in the said letters patent and specification, is the original invention of the pursuer." Now, you cannot say that it was the original invention of the pursuer within the meaning of the issue, if it had been publicly known and practised by others before the patent was granted. It has been said that there was no evidence; but I think that is a mistake—what conclusion the jury have come to I know not—but at the Bradley Iron Works there was such a machine, as Mr. Rutherford acknowledged at the bar, as would have amounted to an infraction of the patent, if the use of it had been subsequent to the patent. Then, that being so, I know not what conclusion the jury may have arrived at. They might have thought that this was a perfect machine, that it was the same machine, and that it had been publicly used. If they had been of that opinion, although it had been abandoned, they ought to have found a verdict for the defendant. Under the circumstances, I regret exceedingly that I am obliged to concur in the opinion that has been

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expressed by my noble and learned friends, that this eleventh exception must be allowed; and the consequence of that will be, that there must be a *venire facias de novo*, and that the case must be tried by another jury.

Lond. Mech. Mag.

On a Method of Registering the Force actually transmitted through a Driving Belt. By EDWARD SANG, Esq., F.R.SS.A., *Professor of Civil Engineering, College, Manchester.*

It is a desideratum to have the means of ascertaining how much force is actually consumed in the working of a machine. Whenever the motion is communicated by the intervention of a belt, or band, this can be very easily accomplished.

When we see a belt passed over two pulleys, and look without any narrow examination at the motion, we regard the action as a very simple one; there is more in it, however, than appears at first sight. For the sake of clearness, let us call the driving pulley the drum, and the other the pulley. The belt passed over them, whether plain or crossed, has two free parts, one of which *draws*, and the other *follows*. If it were possible that no force were needed to turn the pulley, these two free parts would be in the same state of tension; but whenever any resistance is made to the motion of the pulley, the drawing part is distended more, and the following part less, than usual; and experiments show that, within all practical limits, *this change is exactly proportional to the pressure necessary for overcoming the resistance.*

As the movement proceeds, the distended part of the belt is lapped over the drum, and, so to speak, the contracted part is lapped over the pulley, so that the circumference of the drum moves more swiftly than that of the pulley; thus, if the distension be 1 in 100, for 100 inches of the drum there would only be 99 inches of the pulley passed over.

The difference between the velocity of the drum and that of the pulley, thus indicates the pressure needed to carry the drum round. Now, this pressure, combined with the distance through which it acts, gives the force used; and hence the simple difference between the distances passed over by the circumference of the drum, and by that of the pulley, is exactly proportional to the force; *and we have only to contrive some method of registering this difference, in order to have a record of the total force transmitted by the belt.*

There may easily be contrived a variety of arrangements for showing the difference between the motions of the drum and pulley. Thus a pair of indicators may be fitted, one to each shaft, so as to tell the total number of turns made by each; from this number, by help of the measured diameter, the distance passed over by each circumference can be found, and thus the element for knowing the force transmitted can be had.

Or, otherwise, and this, perhaps, is the most convenient arrangement, a light pulley, having its circumference one foot, may be

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brought to bear against the belt on the drum, and another against the belt on the pulley; if these light pulleys have counting gear attached, a simple reading off and subtraction will give the difference of distance.

Having now ascertained the difference between the motions of the drum and pulley, it remains to ascertain by what this must be multiplied, in order to give the force. It is not my object, at present, to enter into the theory of the matter—although this theory presents several points of considerable interest—but to give a practical application of the principle. In order to find out the force due to a single foot of difference, we have to run the pulley unburdened for a considerable time, taking notice of the difference of motion, and then loading the shaft by means of a spring friction-strap with two arms, repeat the observation over as many strokes of the engine, or turns of the drum; in this way we shall have a new difference, and, subtracting the one from the other, we shall have what is due to the force as shown by the friction strap.

When the multiplier for one belt has been ascertained, that for any other belt may be approximately computed, if it be of the same material, by having regard to the relative weights of a foot of each; so that a pair of accurately constructed counters form a portable apparatus, by means of which the force transmitted by any belt may at once be ascertained, the weight, length, and material of that belt being known.

Manchester, Sept. 1, 1842. Edinb. New Philos. Jour.

Solid and Hollow Axles.

A paper, by Mr. J. O. York, who has a patent for hollow axles, was read at a late meeting of the Institution of Civil Engineers, giving an account of some experiments which he has made for the purpose of testing their strength, as compared with solid axles. The paper described the common causes of fracture, attributing it to the concussion and vibration produced by various circumstances, such as a bad state of the line, the sudden opposition of any obstacle on the rail, or the shocks arising from the wheels striking upon the blocks, or the chairs, when thrown off the line. These shocks, which it was impossible to calculate the extent of, it was contended, should be provided for by axles which would bear a series of heavy blows without fracture. The force of vibration, and its tendency to produce fracture in rigid bodies, was then treated of, with its effect in destroying the most fibrous texture of iron where elasticity was prevented, as is the case with railway axles, comparing the action with that upon the axles of ordinary road carriages, where the concussion was reduced by an elastic medium, such as the wood spokes of the wheels, which were bad conductors of vibration. By calculation it was shown that the twisting strain arising from the curves of the railway was of too small an amount to be considered as a cause of destruction to the wheels, or axles, even on lines with curves of short radii; and it was submitted that the requisite qualities in railway axles were—first, the

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greatest possible degree of rigidity between the wheels, to prevent the axle from bending, or breaking, from concussion; and, secondly, the greatest quantity of elasticity and freedom in the particles of iron within the axle itself, to prevent the injurious effects of vibration. It was contended that the hollow axle was better able to resist these strains than a solid one, because the comparative strengths of axles are as the cubes of their diameters, and their comparative weights only as their squares; consequently, with less weight in the hollow axle, there must be an increase of strength, and also that the vibration had a free circulation through the whole length of the hollow axle, no part being subject to an unequal shock from the vibration, and that the axle would therefore receive less injury from this cause than a solid one.

A long series of experiments, which had been made in the presence of Major General Pasley, and numerous engineers, was then read, and showed results confirmatory of the position assumed by the author of the paper. In the discussion which ensued, it was allowed that, theoretically, the hollow axles must be stronger than the solid ones, inasmuch as the same weight of metal was better distributed; and the practical experiments fully bore out the theory. Some curious specimens of solid axles, which had borne a great number of blows before breaking, were exhibited by the Patent Axle Company, from Wednesbury. The quality of the iron was excellent, and, had the same material been manufactured into hollow axles, it was agreed that many of the melancholy accidents upon railways would not have occurred.

Lond. Mech. Mag.

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*Accidents from Broken Axles Prevented.**

We have been favored with an inspection of an ingenious method of preventing a carriage falling in case the axletree should become fractured, patents for which have been secured for Great Britain and the continent. The plan is simple, but effective. Two false axles, of sufficient strength, are placed one before and one behind the axle of the carriage, and connected at each end by a box of metal large enough to take in the nave of the wheel; a groove is sunk round the nave about a quarter of an inch in depth, into which a circular rim in the box is made to fit close, but with sufficient play for the wheel to revolve in it; the box opens in half, similar to a pair of handcuffs, and the axle of the carriage passing through it, the wheel is properly placed, and the box shut and fastened with a screw, keeping the rim firmly in the channel cut in the nave. As long as the axle of the carriage remains sound, these false axles and boxes bear no part of the weight of the carriage; but on a fracture taking place, the pressure is immediately transferred to the boxes supported by the false axles, and the wheel still keeps revolving in its place, held by the rim of the box in the groove of the nave.

Mining Journal.

* This is an expensive mode of attaining the same end, that has already been reached in this country, in a much more cheap and simple manner, by the well-tried contrivance known by the name of its ingenious inventor, as "*Kite's Safety Beam.*"—Com. Pub.

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JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

JUNE, 1843.

Civil Engineering.

Memoir upon the Stability of Revetments, and of their Foundations. By M. PONCELET, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* JOHN SANDERS, *Corps of Engineers.*

[CONTINUED FROM PAGE 295.]

CHAP. III.—*Transformation of Profiles, and relative Stability of Revetments.*

The question of the transformation of profiles, considered under its most general aspect, is of very great utility, and often presents itself in cases arising in practice, particularly when it is desired to construct, under distinct conditions, a profile of a revetment after an existing model, and which offers the same degree of stability. We propose to enter into some developments in regard to it, though confining ourselves to the usual case of the question.

Rules for the Transformation of Profiles with outer face sloping.

67. Ordinarily, we only consider the proper stability of a revetment, without regard to the changes which may take place in the action of the earth. The question of the transformation of a profile, with or without counterforts, then reduces itself to a simple question of statics, in which we propose to give to a new wall, a moment, or a friction upon its base, equal to that of an existing wall. However, if the case is restricted to revetments with the inner faces vertical, and without counterforts, it is easy to perceive the want of exactness in

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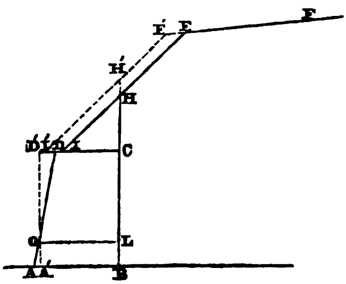
this manner of proceeding, especially when it is applied to demi-revetments.

Fig. 4.



Let there be, for example, a profile ABCD (fig. 4), with its outer face in batter, and another, A'BCD', a transformed vertical one of an equal stability, or the moment of which, with reference to the outer edge passing through A', is equal to that of the preceding one with reference to the point A. It is clear, unless the exterior slope of the parapet retains about the same position with reference to BC, the inner face of the wall; or, which comes to the same thing, unless D'I, the berm of the new wall, equals DI, that of the old wall, plus D'D; that the thrust, or pressure, against this inner face, as well as the load of earth on the coping of the wall, will be modified in a manner so much the more perceptible, as the quantity D'D, and the common height, BC, of the two walls, become greater. Notwithstanding the opposition of the effects due to these two causes, we have seen (21 and 35) that they can, nevertheless, give rise to very appreciable differences in the thicknesses, or moments; which differences will sometimes be positive, and sometimes negative, according to the value of a, the ratio of the height of the superincumbent load of earth, to that of the wall.

The same observation being applicable to the case of sliding, in which the existence of a berm has for an effect, to diminish the thicknesses (see table number 53); therefore, in the present question, it is necessary, for exactness, to suppose such a width to the berm of the transformed profile, that its inner face may nearly preserve the same situation with reference to the mass of the embankment. We say *nearly*, and not exactly; because the outer edge, A, or A', in fact, experiences, with regard to the inner face in question, a displacement AA', which, in case of rotation around this same edge, tends to modify the length of the arm of the lever of resistance, or stability, due to the weight of the prism of earth ICH, which rests directly on the top of the wall. But, as this displacement is slight, and the influence of this prism but trifling, it is unnecessary to investigate it.

68. That granted, if we first consider the case of sliding upon the base AB of the wall, it is evident, without any calculation, that all revetments of the same height, and which have the same mean thickness, also have, on the specified hypotheses, an equal stability and resistance. Thus, for example, if the point O represented the middle of the outer face of any given revetment, ABCD, of Vauban; and it should be required to transform it into another of the same stability relative to sliding, and with an outer face inclined under any angle whatever; it will merely be necessary to draw, through this middle point, a line with the proper inclination to have the face of the new profile, without at all changing the position of the exterior slope IE of the parapet.

$$e = 1.625^{\mathrm{m}} + \frac{1}{5}(H + h - 2^{\mathrm{m}}) - \frac{1}{5}(\tfrac{1}{2}H) =$$

$$(0.2\,a + 0.1)\,H + 1.225^{\text{metres}},$$

which was adopted in number 53. On the same hypotheses, it immediately gives the mean thickness e of a wall with any exterior slope whatever, and of an equal stability with that of the demi-revetments of Vauban. H, h, and a, representing the same quantities as in number 1, and the new berm being regulated in the manner just described.

69. We shall now proceed to the case of rotation, which is the most important in practice (66), and let us undertake to determine, as simply as possible, for a wall ABCD, of the height H, and having the tangent of the inclination of the outer face upon the vertical represented by n, the thickness E, which it must have at the base, in order that its stability may be equivalent to that of a vertical revetment, A'BCD', of the same height, and of an uniform thickness, e. A problem about the same as that which we should have to resolve, if we desired to extend the application of the rules, or tables, presented in the first chapter of this section, to revetments with any slope whatever. If we, moreover, suppose that each wall preserves the same relative position to the common inner face BC, and to the mass of the parapet IEF, we shall have, in order to express the equality of the moments, with references to the edges of the base A and A',

$$E^2 - \tfrac{1}{3} n^2 H^2 = e^2, \text{ whence } E = \sqrt{e^2 + \tfrac{1}{3} n^2 H^2}.$$

70. To shorten the calculation of this expression, which, by the way, does not in itself offer any difficulty, we shall make use of an analytical principle, which consists in this, that we universally have

$$\sqrt{A^2 + B^2} = \frac{\cos \frac{1}{2}(\psi' + \psi)}{\cos^2 \frac{1}{2}(\psi' - \psi)}\,A + \frac{\sin \frac{1}{2}(\psi' + \psi)}{\cos^2 \frac{1}{2}(\psi' - \psi)}\,B,$$

to within a degree of approximation indicated by the value of tang.^{2} $\frac{1}{2}(\psi' - \psi)$ for all that extent of the values of the ratio $\frac{A}{B}$ comprised between $\frac{A}{B} = \cot \psi$, and $\frac{A}{B} = \cot \psi'$.

In the case under consideration, where

$$A = e,\ B = \tfrac{1}{3}\sqrt{3}\,n\,H = 0.5774\,n\,H,\ \frac{A}{B} = 1.732\frac{e}{n\,H},$$

the ratio of A to B can become infinite on account of n, $\psi' = 0$. We therefore have the simpler expression,

$$\sqrt{A^2 + B^2} = (1 - \text{tang.}^2\, \tfrac{1}{2}\psi)\,A + 2\,\text{tang.}\,\tfrac{1}{2}\psi\,B,$$

to within a degree of approximation indicated by tang.^{2} $\frac{1}{2}\psi$.

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On the other hand, n, or the inclination of the outer face of the wall from a vertical, is, in new constructions, always less than $\frac{1}{7}$, or even $\frac{1}{8}$; and by the last column to the right in the table of number 34, we perceive that the ratio a of e to H never passes below 0.198, or 0.2; therefore the smallest of the values of $\frac{A}{B}$ will, in all cases occurring in practice, universally exceed 2.5; which number, being considered as the value of cot ψ, the minimum limit of $\frac{A}{B}$, will finally give:

$$\sqrt{A^2+B^2}=0.991\ A+0.1906B,$$

to within the fraction tang.$^2\ \frac{1}{2}\psi=\frac{1}{110}$, throughout all the extent comprised between $\frac{A}{B}=2.5$, and $\frac{A}{B}=$ infinity.

Then we shall also have to within $\frac{1}{110}$,

$$E=0.991\ e+0.11\ n\ H=0.99\ (e+\tfrac{1}{9}n\ H)\ \text{or}\ e=1.01\ E-\tfrac{1}{9}\ n\ H,$$

for all cases in which the table of no. 34 is applicable; but the batter of the wall must not exceed one in seven.

71. From the foregoing, nothing is easier than to calculate the thickness E at the base of a revetment ABCD (fig. 4), with its outer face in batter, when we shall have obtained, by means of the table just referred to, or by the practical formula (v) no. 40, if the case permits it, the thickness e of a vertical revetment A'BCD' of the same stability, but with a berm equal to D'I. *Add to e the $\frac{1}{9}$ of n H, and subtract from the result the $\frac{1}{100}$ of its value, which, supposing the slope of* AD *to be less than $\frac{1}{7}$, will give to within $\frac{1}{110}$ nearly, the required thickness.*

72. The formula under consideration leads to a method of transformation of profiles analogous to that which has heretofore (68) been presented for the case of sliding; but as it supposes the batter to be less than one in seven, and the ratio $1.732\frac{e}{n\,H}$ of A to B, to be at least equal to 2.5; we have sought to modify it in such a manner as to render it, at the same time, simpler, and more directly applicable in a greater number of cases. If we admit that the thickness of revetments of the same stability, taken at $\frac{1}{9}$ of their height from the base, is within certain limits independent of the slope of the outer face, it is supposing that we have exactly

$$E=e+\tfrac{1}{9}\,n\ H,\ \text{or}\ E=e+0.1906\ \sqrt{\tfrac{1}{3}}\ n\ H,$$

that is to say, $\sqrt{A^2+B^2}=A+0.1906\ B$, for all admissible values of A and B.

But as we have, on the contrary, to within $\frac{1}{110}$ nearly,

$$\sqrt{A^2+B^2}=0.991\ A+0.1906\ B,$$

we see that, if we continue to take the first term of the preceding for-

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mula equal to A, it will be necessary to diminish somewhat the coefficient 0.1906 of the second term, which comes to the same thing as reducing slightly the fraction $\frac{1}{5}$, in the formula $E=e+\frac{1}{5}nH$. Now, a numerical discussion shows that, if we replace this fraction by $\frac{1}{10}$, or take

$$\sqrt{A^2+B^2}=A+\tfrac{9}{10}\,0.1906\,B=A+0.172\,B,$$

which approximates to within less than $\frac{1}{64.8}$ of the true value, for all the extent comprised from $A=2.257\,B$ to $A=\infty$. The error becomes nothing for A infinite, or $B=0$, which answers to the case of $n=0$, or a vertical wall. It acquires its absolute and positive maximum value $\frac{1}{65}$ when $A=5.81\,B$. It returns to zero when $A=2.82\,B$, and then goes on increasing negatively as the ratio of A to B diminishes, which causes it to pass anew by the value $-\frac{1}{65}$, when A is reduced to 2.257 B, or when the ratio of e to H descends to 0.198, at the same time that n becomes $\frac{1}{7}$.

According to the table of number 34, this ratio only falls to 0.198 in the very unusual case where the earth of the embankment unites a very great friction to a very slight density, and is not raised above the top of the wall, which, therefore, does not sustain a superincumbent load. For all ordinary cases, on the contrary, this same ratio will surpass 0.26. We can, consequently, suppose $n=\frac{1}{5}$, without the value of $\frac{A}{B}$, or $1.732\frac{e}{nH}$, descending sensibly below 2.257.

Then, finally, the formula

$$E=e+\tfrac{1}{10}nH,\text{ or } e=E-\tfrac{1}{10}nH,$$

which is based upon the supposition that the thickness measured at $\frac{1}{10}$ *of the height of the wall is independent of the inclination of the face*, is exact, to within $\frac{1}{65}$ nearly of the thickness at the base, for all cases occurring in practice, wherein we take the coefficient of stability equal, or superior, to 1.912 (18), and do not allow the slope of the outer face to exceed $\frac{1}{5}$.

73. We can satisfy ourselves that this very simple rule for the transformation of profiles is equally correct for the ordinary profile of Vauban, and, *a fortiori*, for that of demi-revetments, as long as the height of the masonry does not exceed 18 or 19 metres, which it never would in practice. This, however, requires that we should increase the new berm in such a manner as to give to the exterior slope of the parapet the same relative position with reference to the inner face of the two walls.

74. Considering, in particular, the demi-revetments of Vauban, for which the thickness at the base

$$E=\overset{\text{metres}}{1.625}+\tfrac{1}{5}(H+h-\overset{\text{m}}{2})=0.2\,(H+h)+\overset{\text{m}}{1.225},$$

h being the height of the parapet above the top of the wall, counted from the middle of the superior slope, we shall thus have:

$$e=0.2\,(H+h)+\overset{\text{m}}{1.225}-\tfrac{1}{10}\,\tfrac{1}{5}\,H=0.2\,(a+0.9)\,H+\overset{\text{m}}{1.225},$$

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for calculating the thickness, to $\frac{1}{67}$ nearly, of a vertical wall of the same stability. But, observing here that, in practice, as the height H of the masonry rarely surpasses 12 to 13 metres, the ratio of A to B must constantly exceed the number 2.5.—This permits us to take, with still more exactness, or to $\frac{1}{118}$ nearly of E (71),

$$e = 1.01\,E - \tfrac{1}{5}\,\tfrac{1}{5}\,H = 0.202\,(a + 0.89)\,H + 1.\overset{m}{2}37 = 0.18\,H + 0.202\,h + 1.237,$$

and establishes formula (q) of no. 20, as well as the remarks accompanying it; for, in the transformed vertical profile A'BCD' (fig. 4), the width of the berm DI ought, for exactness, (67) to be considered augmented by the quantity DD', equal to $\frac{1}{5}$ of the height H of the wall, less AA', which, being only the $\frac{1}{47}$ of it, can very properly be neglected in the present question.

75. The profile of Vauban is always accompanied with counterforts, which, it cannot be denied, play an important part in the conditions of equilibrium. The question of its transformation into a new wall, also provided with counterforts, and having an equal degree of stability to that of the old wall, has been a subject of frequent discussion among engineers. They have generally assumed, that a like system would turn in an entire block around the outer edge of its base, and that the moment of its resistance to turning was precisely equal to that of its entire weight, independent of that of the earth which lies above it, and, moreover, without taking into consideration the friction of the earth which is filled in between the faces of the counterforts. For the present, neither contesting nor admitting the truth of this hypothesis, we shall content ourselves with remarking:

1°. That, with regard to its stability relative to sliding upon the base of the wall, it will suffice to preserve, for the counterforts of the new wall, dimensions and a position exactly similar to those of the old one, which must be done either with reference to the counterforts themselves and the back of the wall, or with reference to the exterior slope of the parapet, which should always (67) cover the same quantity of the surface of the top of the wall; for neither the pressure of the earth, nor the weight upon the foundation, will have been changed.

2°. That, with regard to its stability relative to rotation, we shall only modify it in an inappreciable manner, if we assign to the counterforts of the new system the same respective dimensions and positions as those of the old one, while, at the same time, giving to the principal mass of the wall, the degree of stability which is called for by the preceding rules; for the edge of the base A' of this mass (fig. 4) will be displaced by a quantity AA', at the very greatest (74) only equal to $\frac{1}{47}$ of its height BC. This only lessens the length of the arm of the lever of the resistance of the counterforts by the same quantity, for which we can always make an allowance by an equal elongation of the counterforts, or by an equal addition to the thickness of the body of the masonry, and without sensibly increasing the expense. While this secures to the system an excess of stability, it permits us

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to neglect the influence of a change in the berm, which is only perceptible in the case of high embankments.

Of the Influence of Counterforts, and, more particularly, of the Stability of the Profile of Vauban.

76. As long as the transformation is confined to changing the inclination of the outer faces, without altering the arrangement of the counterforts, we can always secure a degree of stability to the new system, clearly equal, if not superior, to that of the old, without being obliged, as will be shown, to resort to any calculations for that purpose. But, when the question is to replace these counterforts in the new profile by an uniform additional thickness given to the mass of the wall, it is quite a different matter. The difficulty presenting itself in this case is owing to the impossibility of discovering the precise part that the counterforts play in the general system of resistances, arising from the force of cohesion which unites them with the body of the revetment, and from the modification which they introduce into the action of the pressure of the earth.

The researches of M. Audoy shed some light on this point. They lead to this conclusion: That, in order to ensure, to revetments without counterforts, a degree of stability equal to that of the ordinary profile of Vauban, it is necessary to adopt a coefficient of stability equal to 4.70 for the case of sliding, and to 3.80 for that of rotation; so that the substitution of the first of these profiles for the second would be quite disadvantageous in an economical point of view. These coefficients actually being nearly double those which answer (18 and 65) to the main body of the wall; and the thicknesses of revetments with moderate loads increasing nearly proportionally with the values of these same coefficients on the hypothesis of sliding, and with their square roots on that of rotation (38); it therefore follows, that the counterforts must be replaced by an uniform additional thickness which is equal to that of the wall, for the first case, and 0.414 of the same thickness for the second case. Now, this result will appear the more extravagant, because, in the case of very high superincumbent loads of earth, the thicknesses increase in still much more rapid proportions, and because it is the larger number, or the greatest of the increments of thickness, which it will be necessary to adopt, if we wish to give to the profile without counterforts, the same statical properties with the one having counterforts.

77. A like consequence, if admitted in an absolute manner, would lead to proscribing entirely revetments without counterforts, for works of fortification; but it is proper to remark that this consequence depends immediately upon the hypothesis of a tenacity in the masonry sufficient to maintain the counterforts always united to the revetment, in either the case of rotation or sliding; this consequence would also appear incontestible from the calculations of M. Audoy, if we only take into consideration the best of masonry, laid in hydraulic mortar, and thoroughly set; but no such fact can be assumed for the old revetments of Vauban, which are taken for the term of comparison. These were generally constructed of an indifferent masonry, and were

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to supposed them to possess.

The demolition of ancient revetments by pick, or powder, has, moreover, often offered the example of the counterforts separated from the mass of the masonry, and of their generally remaining standing in the earth after the fall of the main wall: a circumstance which proves, independently of all calculation, not only that the resistance of counterforts to any displacement from their own position, is universally greater than their resistance to separation from the mass of the wall, but also that they offer, against the thrust of the earth which acts directly upon them, such an obstacle as to prevent their being overthrown.

78. Such examples, and, above all, the consideration of the feeble tenacity acquired by the mortar at the epoch when the embankments were usually made, have even made some engineers think that the main part of the wall of the profile of Vauban had, in itself, all the excess of stability which is practically needed. The function of the counterforts being thus reduced to procuring to the revetments of this profile an additional resistance of a purely military character. But this opinion, already of long standing, is in its turn too absolute; and we shall see, in the following paragraph, that it is in direct contradiction with the opinion given by Vauban, in the *Traité de la défense des places.*

79. In the first place, as to the actual part played by the counterforts before the mortar has acquired its maximum tenacity, it is evident, even supposing them absolutely detached from the revetment, they do not the less lend a very efficient support to it:—1°. In diminishing, in a marked manner, the extent of the surface of the back of the revetment subjected to the direct action of the pressure;—2°. In diminishing, likewise, the proper energy of this action, either through the resistance which the sides of the counterforts oppose to the sliding of the earth, or through the conoïdal form which the surface of rupture of the earth is forced to take; or, finally, through the earth forming, in certain cases, a horizontal, or inclined, arch, springing from the faces of the counterforts, which the ingenious experiments of Moreau and Neil show to be possible. Consequently, it is not correct to say that the counterforts exercise no influence, even in the case of dry masonry; and although, in the actual state of the question, it may be nearly impossible to estimate this influence, we must none the less admit its existence.

In the second place, there is nothing authorizing us to think that the profile of Vauban without counterforts could have resisted, in all cases, the action of the pressure of the earth—that is to say, for all kinds of earth and masonry to which it has been applied; we are indeed justified in affirming the contrary, either as to the effects of sliding, or as to the effects of rotation, considered at the epoch when the wall is first finished. It is an assertion we have already advanced, and which it is here proper should be clearly established, without, however, running into any long calculations, or even going beyond

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the example offered by the ordinary revetment of ten metres high, with a parapet of only two metres above it.

80. Under the head of sliding, we actually find, in the case for which $p' = p$, and $f = 0.6$, which is not perhaps the most unfavorable hypothesis possible,* that the ratio of the weight of the revetment, and of the earth which covers it, to the effort of the pressure, is solely 1.16; so that the friction of the masonry imperfectly set, seldom exceeding 0.7 of the pressure, the resistance is found reduced, in like cases, to $0.7 \times 1.16 = 0.812$ nearly of the pressure; in this we have entirely excluded any influence of the counterforts. We obtain results much shorter still of a perfect stability, in considering the possibility of rotation; for we then find, for the same kind of earth and masonry, that the moment of the weight of the wall, and of its immediate load of earth, is only the 0.71 of that of the thrust arising from the pressure of the earth. Or, it may be expressed, the reduced thickness, or that at $\frac{1}{10}$ of the height H of this wall (73), which in reality is only equal (20) to 0.342 H, should, from the table of no. 34, be the 0.563 of H, if we wish to insure it a degree of stability which answers to the coefficient $\delta = 1.912$, adopted in the calculation of that table, and only the $\frac{0.563}{\sqrt{1.912}}$, or about the 0.408 of H, if we desire merely a strict equilibrium for which $\delta = 1$; since the thicknesses of vertical revetments sustaining small loads, are sensibly as the square roots of the adopted coefficients of stability (38.)

These last consequences, relative to the possibility of overturning the mean or ordinary scarp of Vauban, would be but very slightly modified even if we take into consideration the increment to the stability which results from the addition of the counterforts; because we have seen (76) that the additional thickness of the masonry which would follow from it, cannot at all exceed the 0.414 of the reduced thickness of the wall, or $0.414 \times 0.342\ \mathrm{H} = 0.142\ \mathrm{H}$, which gives a total thickness $(0.342 + 0.142)\ \mathrm{H} = 0.484\ \mathrm{H}$, yet still less by $\frac{1}{6}$ than 0.563 H, the quantity which our table gives; but if it were reduced to its true proportions, it would probably differ very little from 0.408 H, the thickness answering to a strict equilibrium.

81. After that, we cannot certainly maintain that it would be necessary, in the calculation of the table of no. 34, to take equally into consideration the excess of stability due to the counterforts of the ordinary profile of Vauban, and more especially that it would be necessary to replace the coefficient 1.912, which was used in the calculation of that table, by 3.80, the one which M. Audoy decided on. For in the case under discussion in which $p' = p$, $f = 0.6$, there would result a much greater difference still between the stability of this profile even with its counterforts, and that of the one which, it is maintained,

* Some experiments show that certain embankments formed of large round pebbles, and having all the interstices filled with a fine sand, may weigh as much as 2300 kilogr. a cubic metre, with a slope not exceeding 33°, which gives $f = 0.577$; and as the weight of some kind of brick masonry scarcely reaches 1700 kils., we therefore would, in that case, have p' no greater than 0.74 p.

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main body of the wall, equivalent in volume to the counterforts, or having the same moment with them—a rule sometimes adopted—we can satisfy ourselves that, for the ordinary scarp, ten metres high, it would, at the most, augment its reduced thickness by the 0.22 of its value in the first case, and by the 0.26 in the second; which would, consequently, be far from offering the necessary chances of stability in the most unfavorable hypothesis to be considered.

82. Moreover, it is not amiss here to recal, that Vauban himself judged his profile to be insufficient under many circumstances. In such cases, he acknowledged the necessity of relieving the walls, until the masonry became set, from the effects of the action of the pressure of the earth. The care with which he then recommended the lessening of this action, either by means of alternate beds of fascines and well rammed layers of earth, or by diminishing the intervals between the counterforts; this care, I remark, is an incontestible proof of his opinion, and one to which it would be useless to add anything. On the other hand, if we wish to consider the most favorable cases to stability with regard to the nature of the earth and masonry, we should then find that the revetment of Vauban possesses by itself such an excess of stability, that the adding of counterforts to it would be running into an extravagance in expense which would not be compensated for by any addition to the purely military qualities of the work.

83. Let us, therefore, once more conclude, that, in order to reconcile economy with solidity in constructions, it is henceforth indispensable to pay strict attention to the actual qualities and character of the earth and masonry, as, indeed, both theory and simple reasoning would indicate. Experiments, which could scarcely have been made in the time of Vauban, can now be tried with great facility. It would be quite inexcusable to confine ourselves to the by no means universally correct hypothesis of mean earth and masonry, even though we should propose, with some engineers, to modify the coefficient of stability according to local circumstances. It would leave too much open to chance, since it is impossible to determine, in any absolute manner, the stability of existing profiles, without taking into consideration the earth and masonry.

On the other hand, if, while continuing to admit the hypothesis of the *mean case*, as it is termed, we attempt to regulate the thicknesses of revetments, after the stability of the profile of Vauban, directly transformed, or replaced by equivalent formulas not less restricted, even though they should be those of the 15th, and following, numbers of this section, it would not be too much, as has been shown, to add, in certain cases, to the principal wall, counterforts such as he prescribed. We would only be justified in replacing them by an uniform additional thickness to the mass of the wall, as long as we should rigidly take into consideration all the essential given quantities of the question, in adopting, for example, the coefficient of stability 1.912, and the method of calculations exhibited in the 36th, and following,

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numbers. Because, from the great magnitude of this coefficient, and from the hypotheses settled (2) in favor of the resistance, these methods appear to us to suffice for all the usual cases, and to leave no chance open to uncertainty, even with regard to the sliding of the masonry upon the beds of its courses (66).

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 307.]

SECOND COURSE.—LECTURE VI. ON THE GAUGE OF RAILWAYS.

After some preliminary observations, illustrating parts of the last lecture, and particularly in reference to what was stated respecting the Brighton Railway, Mr. Vignoles proceeded to enter on the subject of the breadth, or gauge, of railway, which he explained to denote the distance between the iron bars which form the track, or way. The definition of the gauge of the old tramways, introduced the observation, that, from their form, being, as it were, an artificial rut, they were styled by the French *ornières*, of which the literal translation was "wheel-rut." The present ordinary railway gauge was 4 ft. 8½ in., and some speculations were made as to the choice of such a particular breadth, and quotations were made from Mr. Wood's *Treatise on Railways* to show that it had been owing to an accidental circumstance, viz.,—that the first conclusive experiments on the principle of the present locomotive engines had been made on the Killingworth Colliery railway, which was laid to that gauge. In some of the first of the acts of Parliament for modern railways, it had been made imperative, by a special clause, to adopt this particular gauge, and many companies submitted quietly to the enactment, thereby preventing all chance of improvement in what was assumed to be perfect *ab initio;* but, about six years ago, much discussion having taken place as to the proper gauge, this decree was altered, and there is now no limitation in the width of the gauge, which is left entirely to the discretion of the engineer. Now, the consequence is, that although it would be desirable that there should be a standard gauge fixed, yet, so divided have the public been as to what is the right one, that we have at present no less than seven different gauges used throughout the United Kingdom; some of the Scotch lines, for instance, have a gauge of 4 ft. 6 in., and others of 5 ft. 6 in. The Eastern Counties Company have adopted 5 ft. The gauge of the railways in Russia is 6 ft. On the recommendation of the Irish Railway Commissioners, the Belfast and Armagh Railway Company have made their gauge 6 ft. 2 in. On the Great Western Railway, the gauge is 7 ft. Now, as much as 18 years ago, Mr. Tredgold, a celebrated and scientific engineer, made the following observations:—"The width between the rails being dependent on the height of the centre of gravity of the loaded carriage, and this again varying with the nature of the load and the velocity, it will be obvious we cannot

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do better than make the breadth between the rails such that, by disposal of the load, the centre of gravity may be kept within the proper limit in either species of vehicle, whether swift or slow, and it would be desirable that the same breadth, and the same stress on a wheel, should be adopted on all railways. We would propose 4 ft. 6 in. between the rails for heavy goods, and 6 ft. for lighter carriages to go at greater speed." Now, it is remarkable that, during all the discussions that took place with regard to the gauge, this observation was never referred to. When Mr. Brunel broke through that fixed number for the gauge, and adopted another, he gave very strong and sound reasons for so doing; whether he was right in assuming so high a number as seven is questioned by many, but the principle upon which he went was this—"I have (said he) laid out the line as nearly level as possible; the curves that I have adopted are nearly equivalent to straight lines; I keep the centre of gravity low, by placing the body of the carriage within the wheels, and anticipating greater stability and steadiness, I shall be able to go at a much higher speed, and with much more assurance of safety." The Irish Commissioners argue thus—"From the nature of the locomotive engine, its power is so great in proportion to the friction it has to overcome, that it is capable of drawing a load which (even with a greatly increased breadth as compared with common road carriages) extends to a very considerable length, and, in order to reduce this length as much as possible, it is necessary, with the present breadth of way, to make the wheels run within the frame which supports the carriages; the seats of the passengers are, therefore, placed above the periphery of the wheel, which, for the sake of lowering the height of the centre of gravity, is made as small as possible."

One great theoretical objection, therefore, to the narrow gauge, is the increased friction consequent upon the reduction of the diameter of the wheel, since, besides what is due to the load, the friction of a wheel, at the axle, may be said to depend upon the proportion of the diameter of the wheel to the diameter of the axle; but, in attempting to carry out this principle in practice, the axle has sometimes been turned down so small as to produce much greater and more positive inconveniences; and it is very questionable if it be prudent, or desirable, to make the proportion between the wheel and axle greater than 15 to 1, and which proportion can be obtained with 3-feet wheels. Now, with a 4-feet wheel and a 3-inch axle, the proportion being 16 to 1, it may be well doubted if, on this account alone, the large wheels are worth their greatly increased cost. The commissioners, however, urged that the same carriage room may be preserved by extending the breadth of bearing of the rails, so as to allow the wheels to run outside the frame, instead of running within it, in which case we can bring the body of the carriage down to the axletree. The gauge may be thus increased from 4 ft. 8½ in. to 6 ft. 2 in. —thus arguing for an increased breadth, that the centre of gravity may be lowered, and the diameter of the wheels thereby reducing the friction, and increasing the power, to overcome the "surface resistance." This is, in other words, getting more leverage; but such an

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advantage, however, does not apply so much to railways as to common roads, for, on the railway, there is little, or no, obstacle to be found in the shape of surface resistance, except what are as a few grains of dust compared with the obstacles to be found on the common road, or the deep ruts in a wood, which require very large wheels for the timber wain. "At the same time, (continued the commissioners,) the load itself may be reduced in height, the bottom of the carriage, or truck frame, being, in this case, limited by the axle-tree of the larger, instead of the periphery of the smaller, wheel; and, with this reduction of height, the wear and tear will be reduced, and the ease of the motion increased. Moreover, the force to be overcome being less with the same load, we may, by retaining the power of the engine the same, carry a greater load than at present with the same velocity, or, retaining the same load, carry it at a greater velocity by increasing the diameter of the driving-wheels of the engine; or, if it be not desirable to increase the velocity, the speed of the piston might be reduced, which would be a great practical advantage; or, lastly, preserving the same load and velocity, the form and weight of the engine may be made less, and, probably, the one or other of these arrangements would be adopted, according to the nature of the traffic on the railway. Thus, in passenger and mail trains, it might be desirable to increase the velocity, whereas, in the carriage of heavy goods, it would be most economical to increase the load." "But (say the commissioners) there is a point which must be attended to, and that is, that the whole of the advantages apply only to level lines." Now, the Great Western was thus susceptible of having a wider gauge, since the line was made nearly level, for, as the commissioners observe, "in ascending the various gradients and inclined planes, the load has to be raised in opposition to gravity, and the power necessary to effect this is frequently equal to, or exceeds, that which is employed to overcome the friction, and will remain the same to whatever extent the friction is reduced. To avail ourselves fully of the reduced friction, those planes which cannot be worked by assistant power require to be reduced in their slopes, in the same proportion that the wheels are increased, or, otherwise, that assistant power be applied on proportionably less slopes than according to the present practice"—that is to say, that the power of the engine is employed in overcoming the friction of the load, and in raising it up the several ascents, and what is gained by increasing the breadth of the railway and making the wheels run outside the frames, is only applicable to the former, the latter remaining the same as before; "and the advantage of the alteration would be overrated if this circumstance were not taken into consideration." Thus it is that the additional advantage arising from the diminution of friction is so small, when you come to other than nearly horizontal lines, that the advantage is lost. There is yet another reason for increasing the gauge, viz., that we are enabled to construct the machine without being cramped in space for the moving parts, and affording a larger diameter for the boiler; it was this consideration, probably, which first induced practical engineers to pay attention to increasing the gauge above 4 ft. 8½ in. If

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we had to begin railways again, we should certainly make the gauge wider than 4 ft. 8½ in. In laying out future lines, particularly where the traffic is not great, the point of consideration will be to obtain the greatest advantage at the least expense, and to determine how much the gauge ought to be increased; and Mr. Vignoles stated, that, after having paid a deal of attention to the subject, he gave it as his opinion that a gauge of six feet would be amply sufficient to satisfy all reasonable conditions. The Irish Railway Commissioners had observed "that, at present, the load is seldom equal to the power of the engine, and, this being the case, but little would be gained by a greater breadth of road," with a view only of reducing the resistance, already much inferior to the power by which it is to be overcome, except by allowing an increased speed on the line generally, and on the level planes in particular. With a full and overflowing traffic, there is no doubt it would be advisable to employ the greatest possible breadth of bearing; but it is useless, or worse than useless, to incur a present expense for a benefit which it is not likely that there will ever be the means of taking advantage of, so that, unless under the cirumstances just mentioned—viz., an incessant traffic—Mr. Vignoles thought that a seven-feet gauge was over the mark. Mr. Vignoles stated that the consideration of curves was connected with that of the gauge, that it was a most important element in the consideration of railways, and would be taken up in another lecture. The rule given for raising the outer rail, on curves, required the gauge to be included as one element in the calculation, as also the height of the centre of gravity above the rails, which was also contingent on the gauge, as before explained.

LECTURE VII.—ON CURVES OF RAILWAYS.

This lecture was devoted to the consideration of curves upon railways, and Mr. Vignoles pointed out the principles on which should be compared the economy and advantages to be obtained by the adoption of curves, with the inconveniences attending on them; the saving of expense in formation, earthwork, bridging, &c., by curving round natural obstacles; the advantages of attaining a more level line, avoiding interferences with valuable property, or approaching towns, mineral or manufacturing establishments, &c., all entering into the former—the practical inconveniences of additional resistance to motion and retardation of velocity, to ensure safety, being the set off; and, among other elements, it was stated that the breadth, or gauge, of the railway affected the calculation. The Professor then showed that along very wide valleys, through champaign countries, and where the grounds undulated, so that the ridges, dividing the watercourses, were successively crossed by the railways at right angles to their general direction, the saving by lateral deviation would seldom be material, and, consequently, that the curves may be laid out so flat as to be practically equivalent to straight lines—the "*accidens de terrain*," to use a French phrase, being, in such districts, to be overcome by cutting and filling, to the extent justified by the importance of the line and traffic, or by the introduction of undulating gradients, some-

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what approximating to the natural surface of the country. But, in tracing a line of railway along the sides of hills bounding narrow valleys, particularly where the main valley is broken by lateral rivers, then the economy from curving becomes very great, and the introduction of curves to the greatest possible extent, consistent with safety, is allowable.

Mr. Vignoles then went on to consider the various means employed to obviate the practical inconveniences arising from curves on railways. He began by explaining the peculiar distinction in make between carriage-wheels and axles constructed for running on railways, and those for common roads—in the former the wheel being keyed fast to the axle, and both moving round together—in the latter the axle being fixed to the carriage, the wheels only moving round. Many attempts had been made by engineers to give the railway vehicle the advantage which the road carriage had, of turning with facility and safety round sharp bends, but in vain, as the wheels always got off the rails laterally, at even moderate velocities; it was only on the old tramroads that the wheels were loose on the axles. Railway wheels, being thus fixed to the axles, have the tendency to move on a straight line, so that, on the occurrence of a curve, the effort to continue in motion in the direction of the tangent of that curve, creates a certain degree of resistance, as the wheels are only kept upon the rails by the flanches pressing against the inside edge of the outer rail of the curve. The Professor then entered into a number of technical details, which he illustrated to the class by diagrams, explaining why the flanch of the wheel had now, by common consent, been placed on the inner side of the periphery of the wheel, rather than on the outer side; and also the reason for allowing a certain amount of play, being the difference between the gauge of the rails and the gauge of the wheels, and the manner and cause why the rim of the railway wheel is made somewhat conical—that is, the wheel, instead of being quite cylindrical, is really the frustrum of a cone—stating at the same time, the rule for giving the proper "cone" to the wheel, being dependent on the *minimum* radius of curvature on the line to be traveled over, and the *maximum* velocity. In general, the "cone" was stated to be about one-seventh of the breadth of the rim of the line, giving about one inch for the difference of diameter of the wheels at their inner and outer edge, for, when carriages are passing round a curve, the wheel and axle, being connected, roll together as a rigid body, and require the contrivance of the "play and the cone" to prevent too much lateral friction of the flanch, and to get the wheel round the curve without dragging. Mr. Vignoles then showed that, on the ordinary railway gauge of 4 ft. 8½ in., and in the 3-feet wheels, the above amount of cone and play would be sufficient to meet a curve of only two hundred yards radius, which is greater than any which ought to be laid down on a traveling line for high speeds.

The centrifugal force due to the velocity of the carriage, was next to be considered. As before stated, its tendency in moving round a curve is to keep a tangential course; this force may be accurately computed (being dependent on the velocity of motion, weight of the

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carriage, and the radius of curvature) by well-known formula, whence is deduced the fractional part of the weight of the carriage, representing the centrifugal force. The Professor gave the formula, and worked it out on a supposed velocity of something more than seventeen miles per hour, or about 25½ feet per second, on a curve of 200 yards radius, whence the centrifugal force was found to be $\frac{1}{30}$th of the weight of the carriage. Mr. Vignoles quoted the following rules, viz., "multiply the square of the velocity in feet per second by the gauge of the railway, and divide the product by the accelerating force of gravity, multiplied by the radius of curvature in feet," which gave an expression, which, though not the fraction of the weight, was what would do very well for practical and ordinary purposes; it was the height which the outer rail of the way should be elevated, to counteract the centrifugal force, and prevent the wheel flying off at a tangent to the curve. He then stated M. de Pambour's more strictly mathematical, but more complicated, rule for obtaining the same amount of elevation of the outer rail, and showed the table of results calculated by that engineer and by Mr. Wood, of which we only give the extremes, by which it appears that, supposing it safe to encounter so sharp a curve as one of 250 ft. radius, at the rate of 30 miles an hour, the outer rail of the way must be elevated 12 in.; but for a radius of 5000 feet, or nearly a mile, at the rate of 10 miles per hour, the requisite elevation is only one-sixteenth of an inch. Having elevated the outer rail, the axle of the carriage, resting on the two rails, gets such an inclination as will produce on the load a gravitating force inwards equal to the centrifugal force outwards; and there will neither be any tendency in the carriages to upset, nor to press the flanches of the wheels against the rails. The rails once laid, if the carriages run slower than the calculated rate, the centrifugal force is overbalanced by gravitation, and the flanches of the wheel press the inside rails; if quicker, the contrary effect takes place, and the flanches press against the outer rails, so that some medium rate of traveling must be fixed on; and, as the slow trains are in general most heavily laden, any increase of friction has a more powerful effect of retardation than will occur to lighter loads moving at greater speed. Mr. Wood, therefore, advises that the outer rail should not be elevated more than will compensate the centrifugal force produced at the slower rates of motion with heavy trains. Mr. Vignoles then forcibly illustrated the practical effect of neglecting these rules.

He then entered on the subject of laying out curves on the ground, by a succession of set-offs at the end of each length of any given measure—the set-off being calculated from the radius of curvature, considering the given measure (say a chain length) as the side of a circumscribing polygon; and, on the large scale, and practically, a number of these sides of a polygon become the segment of a circle. Mr. Vignoles gave a simple approximate rule for finding the set-off from the radius, or the reverse, by "divide the number 792 (the number of inches in a chain) by the radius in chains—the quotient is the set-off per chain in inches." Thus, the set-off per chain for a curve of a mile radius is 9.9, or, in round numbers, 10 inches. When the curve

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is of less than one mile radius, it is advisable to make the set-offs by half-chains. It was observed incidentally by the Professor, from the same rule, the set-off due to the curvature of the earth was, in round numbers, about eight inches per mile, and hence had arisen formerly some curious engineering mistakes, from supposing that a horizontal line was a tangent to the earth's surface; and, in setting out canals, an inclination of eight inches per mile had more than once been given to the water line, while it was imagined it had been laid out for a dead level. In conclusion, Mr. Vignoles mentioned that some further observations on curves would occupy the next lecture.

(To be continued.)

Sectional Sketches of Cast Iron Rails, suitable for Railways of general trade. By CHARLES MOERING, *Captain of Engineers in the Austrian Service.*

The writer—having, in the course of his visit to the United States, had occasion to investigate, with some degree of closeness, the system of railways, and railway communication, at present in action here, upon a development of some three or four thousand miles—was, early in the course of his investigations, struck with the fact that, in the superstructure of their railways, the American engineers *had almost wholly omitted to avail themselves of the abundant supplies of the ores of iron which are to be met with in every quarter of their country, and which, reduced to the simple form of cast iron,* either directly by the smelting furnaces, or recast from the cupola, might—as it appears to the writer—have been used for the rails of most of the railways, with the highest advantage to the prosperity of the internal trade of the country.

And this fact has caused the greater surprise to the writer, from the high and just reputation which the Americans possess abroad, for skilfully adapting their resources to purposes of utility, and for disposing to the best advantage, in their works, the native materials which they have at command.

Owing to the circumstance that the government which the writer has the honor to serve, has but recently undertaken a grand system of railway communication, extending to the very confines of the Austrian territories, and considering the facilities possessed by the empire of Austria for the production of cast iron on the one hand, and the limited, as well as imperfect, character of the few established works for producing malleable iron, on the other—information relative to *cast iron rails* was eagerly sought for by the writer, from engineers and others conversant with subjects of this nature; and, after a deliberate examination of the questions which arose, he was impelled to the conclusion, *that cast iron rails had not been rejected from the American railways in consequence of any defects inherent in that material.* This rejection, or omission, appears to have resulted, partly, from the surprising celerity with which these works were simultaneously urged forward—partly, from the inexperience of many of

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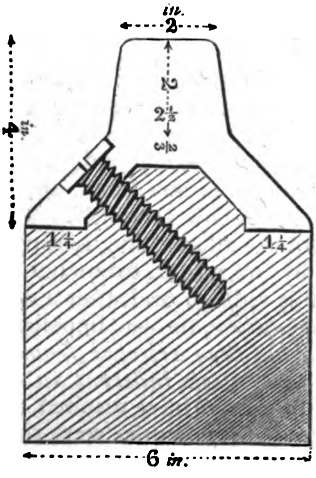
the engineers necessarily employed, in consequence of the great demand at the time, for men of that profession, having induced a number of unqualified persons to throw themselves into it—partly, from a want of due deliberation consequent upon the rapid progress of the railways, which favored imitation, rather than reflection—partly, from the vigor with which rolled iron rails, *then exempt from duty by the law*, were pushed into use, in every quarter of the country, by interested parties—and, partly, from a long chain of fortuitous circumstances, which conduced to the results we have witnessed, *without deciding the merits of the technical questions involved.*

Convinced that, in America, *cast iron rails* have been without just cause neglected, and that, in Austria, and other countries upon the continent of Europe, which, like America, are deficient in the extensive establishments requisite for rolling rails from malleable iron, that *cast iron rails* might be used with signal advantage, the writer projected a few sections suitable for rails of that material under a heavy trade, and collected some from the civil engineers of this country. Three of these sections are sketched below, which may be found of interest to citizens of Pennsylvania at least, since a select committee of their legislature, with Charles B. Trego, Esq., as chairman—a gentleman whose fitness for such a station is well known and duly appreciated here—in a report adopted by the House of Representatives, and extensively circulated, *have declared unequivocally in favor of the use of Pennsylvania cast iron laid upon a continuous bearing of timber, for the railways of the State, whenever these railways shall require renewal.*

So evident appears to be the policy of the recommendations of the legislative committee above mentioned, that the writer humbly hopes the day is not far distant, when the continental powers of Europe (some of whom are as deeply interested in this matter as Pennsylvania is) will adopt a similar patriotic resolution, and make it applicable to those railways, of which the superstructures are not yet laid down.

Fig. 1.



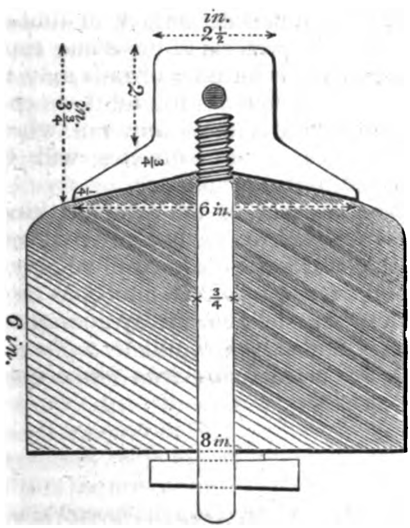
The accompanying section (fig. 1) of a heavy *cast iron rail*, (doubtless susceptible of many improvements,) was devised by the writer in July, 1842, as suitable to the circumstances of the great public railways now under construction by the command of his imperial majesty, the Emperor Ferdinand of Austria. It is designed to be cast in lengths of ten feet, to rest upon a continuous bearing of timber of 6 × 6 inches, to be fastened laterally by good strong screws, (of wrought iron, placed checkerwise,) and weighs about 90 lbs. to the yard lineal. The stringpieces can be easily

shaped by machinery acting upon circular saws, which are to be placed in the proper directions required by the shape of the saddle, or elevation, in the middle of the stringpiece.

Since planning the above rail, some suggestions made to the writer by an able engineer, and further reflection upon the point, have induced the opinion, that the head of the rail ought to project *slightly* upon both sides of the stem, as in Fig. 3; such an outline, while securing abundant strength, would both lighten the rail, and be more favorable to the action of the flanch of the wheel.

The following section (Fig. 2) was sketched for the writer by Mr. Ellwood Morris, of Philadelphia—an American civil engineer, who has devoted a good deal of time to the consideration of *cast iron rails*. This rail also would be the better for a slightly projecting head, as is remarked above.

Fig. 2.



It is designed to be cast in sections of ten feet, to rest upon a continuous bearing of timber, 6 × 8 inches in section; to have imbedded in it centrally, a thick wrought iron wire, or safety rod, to prevent the possibility of accident from breakage, and to be fastened down to the continuous wooden bearing by ¾-inch screw-bolts, three to each rail of ten feet. These screw-bolts will be tapped into the under side of the rails, and keyed up firmly upon a washer underneath the continuous bearing.

This rail, of which the fastenings will be extremely simple, and secure, will, by its saddle form, be difficult to push out of place laterally, and is designed to weigh about 80 lbs. to the yard lineal.

The following section (Fig. 3) was drawn by the writer in January, 1843, to afford a better protection for the continuous bearing, and with the view of employing it under locomotives with more than *one* driving axle, and *running not more than two tons upon any wheel.*

This rail is also designed to be cast in lengths of ten feet, and to be fastened down to its bearing with three bolts to each rail, upon Mr. Morris' plan; three bosses being cast in the hollow part of the rail to receive the screw-bolts, which will be tapped in as in the other case. Screws may also be used, as with the section Fig. 1.

This rail will weigh about 60 lbs. to the yard lineal, and the continuous bearing of wood will have a section of 5 × 5 inches, with sleepers distant from each other in the clear 1 foot 6 inches, and of a triangular section, with the vertex upwards.

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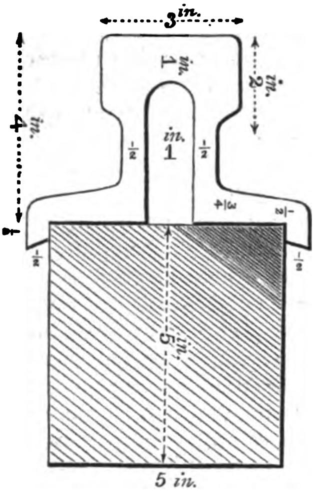
Fig. 3.



More mature reflection upon the proper sectional figure of *cast iron rails,* has induced the writer to think that, to give to a rail of that material a heavy head, projecting half an inch on each side, as in Fig. 3, will be found, in practice, to be the best form for that part; the upright stem must have a good mass of metal, to carry safely the heavy rolling bodies which pass along the surface of the rail; and the base must be broad, to give stability, and distribute the weight over a sufficient surface of timber, which it protects at the same time. Many other outlines of rails may be traced which will fulfil all these conditions, and almost any rail which possesses these requisites will be found useful in practice.

The writer recommends cold blast castings of the toughest kind, run into cast iron moulds, properly heated to prevent any injurious chill; but he believes, however, that it is not necessary to employ a safety rod of wrought iron, as an adjunct to a *cast iron rail,* as he is decidedly of the opinion that *safety* will be abundantly guarantied by the use of a continuous bearing of timber, *which ought to form a leading element in every plan for the use of cast iron rails upon public railways.*

Philadelphia, April 25, 1843.

Report of the Select Committee of the Legislature relative to the Renewal of the State Railways with Pennsylvania Cast Iron Rails.

Mr. Trego, from the Select Committee to whom was referred the memorial of Ellwood Morris and others, citizens of this commonwealth, praying the enactment of a law to provide for the renewal (when required) of the superstructure of the State railways, with rails of Pennsylvania cast iron, made the following report:

That they have given the subject that attentive consideration which they conceive its importance demands, and trust they will be excused for entering into a somewhat extended investigation of the questions raised by the respectable and intelligent gentlemen whose names are appended to the memorial now before the committee.

These memorialists entertain the opinion that, by adopting the use of cast iron rails upon the State railways, when the rails of rolled iron now in use shall require renewing, that the cost of maintaining those roads may be essentially diminished; whilst our own mineral resources will in that case furnish us, in a cheap and simple form, the

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material for the repair and renewal of the superstructure of our railways, without involving the humiliating necessity of resorting to a foreign country for railroad iron, as hitherto has been the case.

In the examination of the matter referred to them, the committee have been induced, for the sake of perspicuity, to consider it under the three following heads, into which it may be conveniently divided:—

I.—*Of the rolled iron rails in use.*
II.—*Of the objections to them.*
III.—*Of cast iron rails.*

In the mineral districts of England, railways came into use about the middle of the seventeenth century; they continued to multiply in number and utility throughout that and the succeeding century, and were generally employed upon descending routes for the transportation of minerals to canals, and other navigable waters.

But, as commercial enterprises, they were unable to compete successfully with canals, until the opening of the Liverpool and Manchester railway, in 1829, produced that celebrated trial of speed and strength between steam locomotives, which developed an extraordinary *saving in the time of transit*, as an additional and most important element in their successful progress; and startled the world by demonstrating the fact, that locomotive steam engines could travel with trains upon railways at the prodigious velocity of thirty miles, or more, within the hour—a speed which had until that time been regarded, even by the ablest writers upon the subject of railroads, as absurd in thought, and impossible in practice.

Since then, the great saving of time effected by railways in the transportation of passengers and goods, has been the chief means of extending their use with a rapidity heretofore unprecedented in affairs of this nature, until they have extended throughout the country, and, assuming to themselves the first rank among our internal communications, have bound distant points together with ligatures of iron, along which a doubled speed of transit has virtually annihilated a moiety of the distance between their termini.

It follows, hence, that every proposition which promises a reduction of the expense of maintaining, or an amelioration in the condition of, that mighty agent, the *railroad system*, deserves, from the State authorities, the most deliberate consideration.

With these preliminary remarks, we shall proceed to consider the three separate branches into which we have divided the subject; incidentally observing, however, that we design to confine ourselves to the consideration of that species of rails technically known as *edge rails;* they being of the kind with which the superstructure of the State railways ought to be renewed, whether rolled or cast iron be the material employed in their fabrication.

I.—*Of the rolled iron rails in use.*

From Wood's standard and well known treatise upon railroads, it appears that *rolled iron rails* of the edge pattern, analogous to those

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now used upon our railways, were first introduced into England in the year 1820, under the auspices of Mr. Birkinshaw, of the Bedlington Iron Works, who had obtained a patent for an improvement in the form of wrought iron rails, and in the mode of manufacturing them by the aid of the rolling mill.

It would thus seem that these rails were brought before the English public, and pushed into use, by parties interested in their manufacture, under cover of the plausible argument, that, owing to the superior strength and toughness of the material, rails of rolled iron could be made so much lighter than those of cast iron, having equal strength, that an essential economy would result to the proprietors of railways from their use. Accordingly, we find that the Liverpool and Manchester railway, the great prototype of the modern railroad system, was originally laid with rails of 35 lbs. weight to the lineal yard; but, although that railway has only been about fourteen years in use, the whole of the original track has been entirely worn out, and is now replaced with rails of much greater weight, the latest patterns of which, indeed, are understood to weigh nearly 75 lbs. to the running yard.

Now, it would appear manifest, that, whatever economy might have been possessed over a cast iron rail of adequate strength, by the light rolled rails originally laid on the Liverpool and Manchester railway; we may at the least assume that their recent heavy pattern, which time and practice designated, cannot maintain any such pretension.

To resist successfully the action of the ponderous motors now employed in the traction of trains upon railways, a certain degree of mass seems to be indispensable in the rails, whether they be of cast or wrought iron; and it may be useful to inquire what weight would at the present day be given by practical men, to a rolled iron rail for a first-class railway, destined to carry upon its surface locomotive engines of the largest size.

Fortunately, we find this question already answered by one of the highest living authorities, (we mean by Professor Vignoles,) himself a distinguished civil engineer, and the constructor of several important railways, who, in one of his recent lectures before the engineering class of the London University, states, in substance, that, in order to withstand the destructive action of the wheels of the heavy modern locomotives, the top table, or button, of a rolled iron rail, in contact with the passing wheels, ought to have a sectional area of *four square inches*, or a weight of 40 lbs. to the yard lineal, whilst the stem and base of the rail will require to have at least the same weight; so that a suitable rolled iron rail for a first-class modern railway, according to Prof. Vignoles, ought to weigh, at the least, 80 lbs. per lineal yard; and if placed in chairs upon detached supports, the supporting metal thus employed would superadd about 20 lbs. weight of iron per yard; so that, finally, a first-class modern railway, with a wrought iron rail suitably adapted to carry the ponderous locomotives of the present day, if placed upon detached bearings, would, in the opinion of Prof. Vignoles, require the use of 100 lbs. of iron in every lineal yard of a single line of rails.

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subject in England, clearly evinces that time has already demonstrated the fallacy of the idea formerly entertained, that very light rolled iron rails might safely be used upon railways, and that a great economy would thence ensue.

Since the tariff enacted by the 27th Congress imposes, from and after the 3d of March, 1843, a duty of $25 per ton on all rolled iron imported into the United States, *including railway bars*, which were duty free by former laws, we conceive that the prices of such iron, if of the superior quality which experience has shown that it ought to be, will scarcely hereafter be less than $60 per ton, delivered upon the wharf in Philadelphia, and hence that it would probably be worth nearly $62 per ton, at an average, when delivered upon the Philadelphia and Columbia railway.

Now, when, to the above prices, and the enormous weight of 100 lbs. of iron per lineal yard of rail, prescribed for a first-class railway by Professor Vignoles, we superadd the fact, that the best railways recently laid in England, and in our own country, have continuous bearings of timber for supporting the iron rails *throughout their length*, which must necessarily remove the strongest objection to the use of cast iron rails,—it does indeed appear to be time to recur to first principles, and inquire, first, what is the object of a good railway? To this question Mr. Wood has furnished the answer, by informing us that "the object of all railroads is, to present to the wheels of carriages a smooth, straight, and level surface." We ought therefore to inquire, secondly, how can we most cheaply satisfy these requisites, without compromising either safety or utility?

II.—*Of the objections to the rolled iron rails in use.*

The main objections to the use of imported rolled iron rails in this State, hereafter, will grow out of their expense, *immediate* or *ultimate*, owing to the duties imposed by the present tariff on the one hand, and the deficient durability displayed by these rails on the other; but further reasons, adverse to their use, may be found in considerations of public policy, as we shall hereafter mention.

Rolled iron rails having once been generally introduced upon railways from economical considerations, many other advantageous properties were supposed to be discovered in them, and to be confirmed by experiments, the fallacy of which time has either since shown, or is now rapidly demonstrating.

That rolled iron rails possessed a very superior and extraordinary degree of durability, as compared with those of cast iron, was a leading one of the erroneous notions formerly entertained, which is still prevalent in some quarters, and the entertaining of which may easily be traced to insufficient experience, or to a want of experiments prolonged through a sufficient space of time; and, in fact, it is not surprising that such an error should be incident to the adoption of a new and captivating system of locomotion, of which rolled iron rails were supposed to be an indispensable element.

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iron driving-wheels attached to locomotives running upon the Killingworth railway, with similar wheels in action upon the same road, but which were hooped with wrought iron tires, that wrought iron rails would probably surpass those of cast iron in durability, in the ratio of about five to one!

This is truly an extraordinary conclusion, but the universal experience of this country having amply demonstrated, that, while the heavy wrought iron tires of the driving-wheels of locomotives, in full action, require replacing annually at least, cast iron driving-wheels suffer much less wear, and, when applied to similar machines, under the same circumstances of work, will run, essentially unimpaired, for several years together; as has been practically shown on several railways, and indicated in the report made to the Canal Commissioners, in December, 1841, by Thomas Tustin, Esq., Superintendent of Motive Power on the Philadelphia and Columbia railroad. We are, consequently, compelled to reject Mr. Wood's conclusions upon this point, as inaccurate in fact, or certainly as being totally adverse to, and unsustained by, the practice upon railways in this country.

To a similar fate must be consigned the conclusions drawn from certain experiments made upon the Liverpool and Manchester railway, in 1831, for the purpose of showing the extreme durability of wrought iron rails, and from which the strong inference was drawn, that the rails experimented upon would probably last half a century, or more! We have, however, a sufficient refutation of the conclusions drawn from these trials of durability, in the fact that the very rails experimented upon, together with the entire track of which they formed a part, have some time since been worn out, and removed from the road.

Such is the easy refutation of some of the fundamental arguments which have been continually advanced and constantly relied on by the advocates of rolled iron railways, and to which, for that reason alone, we have devoted more space than they would otherwise have deserved.

But a few years since, it was proclaimed by our most prominent engineers, that rolled iron rails, of ordinary patterns, would last from forty to sixty years; and this erroneous sentiment formed a most important element in their estimates of the cost of the maintenance of railways. It now appears, however, that upon this point they were so egregiously mistaken, that it has become extremely doubtful whether any of our railways, which carry much traffic, will witness the coming of their tenth anniversary without a renewal of their rolled iron rails, in whole, or in part.

Upon the subject of the unexpected wear, or deficient durability, of rolled iron rails, we will now observe, that it appears from the report of a late meeting of the British Association, published in the London Athenæum, that Mr. Braithwaite, a civil engineer, had called the attention of the mechanical section to the fact, that the rails of the North Union railway, which was opened for travel as recently as the

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year 1838, ***had already required turning.*** From this it appears that but four years' use upon that railway, by an extensive traffic, drawn by the heavy modern locomotives, had sufficed to destroy the top tables of the rails, and render them to a great extent unserviceable,—though, from another source, we learn that they weighed 60 lbs. to the yard, or actually more than the heaviest of the rolled iron rails in use upon the railways of this State.

It should be further remarked, that the expedient of reversing damaged rails can be resorted to *but once*, and that, therefore, it seems certain that those of the North Union railway, notwithstanding their weight, will be entirely destroyed within less than eight years from the date of their first use.

Upon the railway between Baltimore and Frederick, in Maryland, where a new track was laid a few years since, with rails of 50 lbs. weight to the yard, a very extensive peeling off of their top surfaces may be noticed, and many have already been *turned.*

The same evil exists, to a considerable extent, upon our Philadelphia and Columbia railway, as was officially announced to the legislature by W. K. Huffnagle, Esq., the engineer in charge of that road, through the report of the Canal Commissioners for 1841.

In point of fact, both upon the State railways and those owned by companies in Pennsylvania, wherever they have been much used, ample evidence may be seen that the rolled iron rails employed, are rapidly undergoing a process of disintegration, and will, ere long, become so much crushed and laminated, that traveling upon their surfaces will cease to be either safe or practicable.

It would be an easy matter to extend this branch of the subject by a particular reference to several railways; but this course seems to be scarcely necessary, and might be deemed invidious.

It may be alleged by some, that the rapid wear and tear above alluded to, might be obviated by manufacturing the rolled iron rails, hereafter, in a superior manner to that which has been heretofore employed; but it is easy to conceive that increased care in manipulating the iron, or a repetition of the purifying processes, would necessarily enhance the cost to an extent which, when added to the duty, might very probably augment the price per ton to an amount considerably beyond that which we have before referred to, as being the probable limit hereafter.

From the nature of the manufacture, rolled iron rails are made up of laminæ, either disposed vertically or horizontally; the latter is probably the best mode, and would make the most durable rails, but it merely alters the process of disintegration, and does not annul it; for, if rolled with the laminæ vertical, the rails split and crush; and if horizontal, they exfoliate and scale off under the passing wheels, though the latter would seem to be a less rapid process of destruction than the former.

Even if rolled iron rails should be hereafter manufactured in a superior manner, they would still be liable to a new objection, seriously affecting their strength; namely, the crystalization of the metal by the concussions produced from the action of the wheels. The attention

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currence of an unusually fatal accident upon the Versailles railway, in France, where, owing to a sudden fracture, when in motion, of a locomotive axle, originally made of the very best fibrous wrought iron, but which had crystalized by use and become brittle, more than sixty lives were instantly lost.

A close examination of analogous phenomena seems now to have settled the question, that, no matter how tough and fibrous a piece of iron may originally be, yet, if it is subjected to a long series of small shocks, the particles of the metal inevitably re-arrange themselves into a highly crystaline form, and fracture quickly follows.

All railway iron, in use, is subject to incessant percussions, and, consequently, must hereafter be regarded as being peculiarly liable to the foregoing objection.

III.—*Of cast iron rails.*

It has been so frequently shown in the arts, by the successful use of *cast iron* in the construction of bridges, roofs, girders, the principal parts of steam engines, and almost every species of machinery, that this metal is fully competent to maintain the most prodigious strains which pressure can impose, that it would be absurd in any one to argue the reverse; and hence those who object to the use of cast iron rails for railways, have usually confined themselves to the allegation, that, as cast iron is not well adapted to resist shocks, that, therefore, it cannot be made safely to withstand the percussion of railway wheels. This objection, however, is only true to a certain extent, and the error is, that it has been too broadly enunciated, without taking the pains to learn the character and extent of the shocks to be encountered in practice.

The idea is generally prevalent that it is impossible to measure the strains imposed upon the rails of railways by the impact of the driving-wheels of locomotive engines, when moving at great velocities; but such is not the fact,—for we find it stated in an article "*On Cast Iron Rails for Railways,*" written by Ellwood Morris, civil engineer, for the Journal of the Franklin Institute, November, 1842, that the distinguished Professor Barlow has shown, by actual experiments upon the Liverpool railway, conducted with the most delicate instruments, and with the greatest care, "that the vertical stress imposed upon a railway by the transit of locomotive engines, at velocities varying from twenty-two to thirty-two miles an hour, is but little, if any, in excess of that produced by a quiescent load of the same weight!"

Professor Barlow further remarks, that as, from unavoidable imperfections in the road, a strain is sometimes thrown upon a single wheel, equal to about double the quiescent load, as was indicated on several occasions by the deflectometer, during the progress of the experiments, it must therefore be regarded as "an experimental fact, that, with engines of twelve tons weight, (and three tons on a wheel) running at velocities not exceeding thirty-two or thirty-five miles per

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hour, it is not necessary, even as railways have been hitherto constructed, to provide for a strain of more than seven tons, which is allowing a surplus strength of sixteen per cent. beyond the double of the mean strain."

It would therefore seem to be an inevitable conclusion, that, even with detached bearings, if we were to give to a cast iron rail the strength necessary to sustain, with safety, *a quiescent load of treble the weight designed to travel it upon the heaviest loaded wheel*, as has been already prescribed by Mr. Nicholas Wood, we should impart to it a power fully adequate to its purpose.

But we would go still further, and propose that, "to make assurance doubly sure," cast iron rails ought always to be laid upon a continuous bearing of timber, and perhaps also to have imbedded in them centrally, a thick wrought iron wire, as has been suggested by Mr. E. Morris, in the article above referred to, with the view of preventing the possibility of separation between the parts of a cast iron rail thus laid upon a continuous bearing of wood, even if it were fractured, either by design or accident, into many pieces.

That cast iron rails may be safely used upon railways, if of suitable metal, adequate dimensions, and laid in a proper manner, would seem to be rendered certain from the successful experience already had, under rather unfavorable circumstances, with the cast iron rails of the turn-outs upon the State railways, which are mentioned in the memorial committed to us, and which have for that reason been particularly considered.

We find that these rails have a transverse section resembling an inverted U, cast solid, the base being about six inches broad, and seven-eighths of an inch in average thickness, while the body of the rail upon which the wheels run is about two and a half inches wide and two inches high, clear of the flanched base; the sectional area of the profile being about 10½ square inches, and the consequent weight of a rail about 100 lbs. to the yard lineal.

These rails are fourteen feet in length, and are laid, and move, upon *detached bearings* of iron, projecting from a bed-plate, at an average distance of twenty inches asunder; many of them were laid down with the rest of the road, and have been in use since 1835, wearing in a perfectly satisfactory manner, and being now, as we are informed, in a better condition than the contiguous rolled iron rails, though this might perhaps have been expected, from the great weight of the movable rails of the sidelings.

If these rails, forming, as they do, sections of single track fourteen feet in length, at many points of the road, and being, from their position, liable to unusual wear, had been inserted merely as an experiment to test the strength and durability of cast iron rails, that experiment would undoubtedly have been regarded by all as signally successful; and this committee cannot perceive the reason why these rails, succeeding as they do in detached sections of fourteen feet, at many parts of the road, would not answer equally well if brought together in a single line, or if laid continuously for miles to form the track of a great public railway.

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yard, still their success upon *detached bearings* has been so satisfactory, that we must regard it as a fair inference that, with the precautions indicated by us, rails of the solid U pattern, of 80 lbs. weight to the yard, if laid upon a continuous bearing of timber, would equal rolled iron rails of the weight of 60 lbs. per yard, and would be amply sufficient for any of the State railways.

In the present state of the experience upon railways, it is probable that, if the State roads were now to be re-laid, a rolled iron rail, if used, would be laid upon a continuous bearing of wood, and have a weight of at least 60 lbs. to the lineal yard, though even that is considerably lighter than Professor Vignoles has declared to be suitable to the modern practice: and since a cast iron rail of one-third greater weight would equal, or surpass, it in strength, we may with propriety assume that a cast iron rail, of 80 lbs. weight per yard, could be advantageously substituted for a rolled iron one of 60 lbs. to the yard.

As cast iron rails would not cost more than $40 per ton, delivered, let us now compare the probable relative cost, per mile, of a single track railway, laid with each kind of rails, as follows:

94	tons of rolled iron rails, (60 lbs. per yard,) at $62,	$5,828
125	" of cast iron rails, (80 lbs. per yard,) at $40,	5,000
	Saving per mile of single track railway,	$ 828

So that, if we may in this way save even eight hundred dollars per mile of single track, it would, in relaying two tracks of the length of the Philadelphia and Columbia railway, effect an aggregate saving of nearly $130,000.

With regard to the probable expense of maintenance in a cast iron railway, Mr. Zimpel, a German engineer, in a recent work on railways, states, on the authority of an English civil engineer of distinction and experience, that cast iron railroads may be kept up with but a moiety of the outlay required to maintain those of rolled iron.

It has been alleged by some that, upon a cast iron railway, the adhesion of locomotives would be so deficient as to form a strong practical objection; but from a consideration of the loads drawn upon the Philadelphia and Columbia railway, by a locomotive engine with cast iron driving wheels, noticed in an official report by Mr. Tustin, the Superintendent of Motive Power, as being equal to those drawn by other engines; from the experiments upon the sliding friction of iron which have been made by philosophers in Europe; and from the practice in those railways here, where cast iron driving-wheels have long been successfully used—we cannot regard this objection as having much weight, because the loss of adhesion, if any, must necessarily be slight.

It would be easy to reinforce, by further arguments and other illustrations, the favorable position which we have taken towards cast iron rails, but the extent to which this report has already pro-

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longed itself, induces us now to conclude with a few more brief observations.

Concluding Remarks.

In the earlier stages of the organization of the modern railroad system, it was doubtless politic in the general government to encourage the extension of this novel and rapid mode of intercommunication, by exempting railroad iron from duty; but, in the progress of events, the time has now arrived when Congress have wisely taken away that boon, never again, we trust, to restore it; for the day has come when the admission of iron, duty free, no longer benefiting the country to a commensurate extent, would simply be the means of enriching foreign iron masters at the expense of our own native industry; and with the full knowledge of the wants of railways, derived from actual experience, we may now recur with confidence to our own mineral treasures as a source for the supply of our own railways with our own iron.

The statistics derived from the census of 1840 announce the striking fact, that of the 286,903 tons of cast iron now annually manufactured in the United States, 98,395 tons are produced by the 213 furnaces of Pennsylvania alone; an amount of cast iron which, whilst it is more than one-third of the aggregate product of this metal annually in all the states and territories, is nearly treble the quantity manufactured by any other single state in the Union.

Here, then, is an interest of vast importance, which may be nurtured and promoted by the adoption of cast iron rails for railways; and surely the highest considerations of public policy should prompt the authorities of such a State as this, to foster and encourage a leading branch of manufacture from our own native material, by requiring the use of Pennsylvania cast iron upon the State railways, even if the cost of rails of that material should exceed, and not fall short of, that of others.

Finally, the committee would observe, that though they fully concur with the views expressed in the memorial, as to the expediency of the proposed measure, yet, considering the near approach of the period fixed for the adjournment of this legislature, and the amount of public business which yet remains to be disposed of, they have not thought it advisable to report a bill. Neither do they conceive any immediate legislation on the subject to be actually necessary, inasmuch as the Canal Commissioners have full power to act in the case, and to direct in what manner the State railways shall be hereafter renewed.

To that Board, then, they respectfully and earnestly recommend a thorough and impartial investigation of the subject, and an attentive consideration of the arguments and facts stated in this report, believing that they will see the expediency of renewing, with rails of Pennsylvania cast iron, at least so much of the State railways as may serve fairly to test, by actual use, the comparative merits of cast and of rolled rails, when subject to equal circumstances of trial. They therefore offer the following resolution:

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Resolved, That the committee be discharged from the further consideration of the subject.

Report by Major General Pasley, on the Breaking of Axles, and other Causes of Accidents upon Railways generally.

RAILWAY DEPARTMENT, BOARD OF TRADE, Whitehall, 23d December, 1842.

My Lord—After the unfortunate accident which took place on the 8th inst., on the London and Birmingham Railway, I went to the Vauxhall terminus of the South Western Railway, to inquire into an accident, unattended with personal injury, which took place on that railway on the 10th inst., from the breaking of a crank-axle of one of their six-wheeled locomotive engines. On inspecting the fractured iron, it seemed to be of good quality, but had been made in an improper manner, by welding flat parallel plates together, contrary to the usual and more perfect custom. At that station I had an opportunity of comparing six-wheeled and four-wheeled locomotive engines, and I have made the same comparison since on the Croydon Railway; and I now beg leave to submit to your lordship the result of my observations and reflections upon railway accidents, whether depending on the construction of the locomotive engines, or other causes.

1. *The usual construction of locomotive engines compared.*

Four-wheeled engines, with inside bearings, are exclusively used on the London and Birmingham Railway, in compliance with the opinion of Mr. Bury, the superintendent of the locomotive department of the company; and, as the axles of those engines had often been broken without any disastrous result, and that railway (which is extremely well managed) had been as free from accidents, if not more so, than any other; I did not feel myself warranted in making any official remarks in depreciation of four-wheeled engines, until the recent accident of the 8th instant. In that accident, the fore axle of one of their four-wheeled engines broke off transversely close to the inside of the nave of the wheel, so that the wheel was thus, as it were, entirely cut off, and got away from the engine, which, therefore, by having three wheels only, lost its former direct motion, and moved round with a circular motion, which threw it off the rails and carried it down an embankment, where it rolled over and was found with its head reversed, that is, pointing in a contrary way to its original course, so that it must have described a semicircle before it stopped. Further particulars relating to this accident were reported in my letter to your lordship of the 13th inst.

In conversing upon the subject with Mr. Bury, and with Mr. Creed, the Secretary of the London and Birmingham Company, these gentlemen both declared their opinion that the same would have happened to a six-wheeled engine, under the like circumstances; but there were none but four-wheeled engines on that railway, so that I

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could not make a personal comparison of the two sorts at the period of the conversation alluded to. Having since done so with great attention, as before mentioned, and having allowed myself ample time to consider the question, I think it my duty, with due respect for those two gentlemen, to record my dissent from their opinion.

In the case of any of the axles of a four-wheeled engine, of the London and Birmingham Railway pattern, snapping off short close to the inside nave, the wheel must necessarily get away altogether, there being no outside framing to confine it.

In the case of the fore axle of a six-wheeled engine with outside bearings breaking, on the contrary, as the journals are outside, the fracture must necessarily be between the bearings; in which case the experience, not only of six-wheeled, but even of four-wheeled, engines proves that no serious danger is likely to result. It has been urged, and I believe justly, that, when an axle breaks between the bearings, the wheels are more deranged, and more liable to leave the rails, by the outside, than by the inside, mode of fixing; but the fore wheels of a six-wheeled engine with outside bearings cannot get away altogether under any circumstances, unless an axle were to snap short off in two places at once, close to, and on, each side of the nave of one of these wheels, which is impossible. Setting aside, therefore, the supposition of a double fracture, if the fore axle of a six-wheeled engine breaks, no matter where, the wheel is confined closely between the strong frame of its outside bearings and the smoke box, which is also sufficiently substantial, so that it cannot possibly disengage itself entirely. Hence the train may be retarded and stopped, but the engine can neither break down, nor be thrown violently off the rails; in short, no accident injurious to the safety of passengers is likely to occur. If the crank, or centre, axle of a six-wheeled engine should be fractured, the fore and hind wheels alone are capable of supporting the whole weight of the engine, so that it cannot break down. If the hind axle of a six-wheeled engine should break, and even supposing an impossibility, namely, that both the hind wheels should come off, no result injurious to the public safety can be apprehended, because the centre of gravity of locomotive engines of this description is a little in front of the centre axle, and therefore the engine will still remain in the satisfactory state of stable equilibrium.

Having thus stated my opinion, and the grounds on which I have formed it, as to the superior safety of six-wheeled engines, I beg leave to report on the nature of accidents likely to be attended with danger to railway passengers.

2. *Collisions of trains, or locomotive engines.*

Collisions of trains meeting each other, which are the most dangerous, cannot take place on railways having double lines of rails, if the switches are self-acting, and such that no train going at full speed can quit its own line, on coming to the points where the crossings are laid out, by any carelessness of the engine-driver.

Collisions from one train running into another from behind, cannot possibly be prevented by any mechanical means. If the regulations

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happen, except in the case of intoxication. Sobriety is therefore indispensable in this class of men, for, without it, all other qualifications go for nothing.

3. *The breaking down of locomotive engines, or railway carriages.*

If a locomotive engine, or its tender, breaks down at the head of a train, the carriage immediately in the rear of the tender suffers the most, and the second and third carriages also may be more or less damaged. Generally, in cases of this kind, the carriage next to the tender is dashed to pieces, or nearly so; and the passengers, when any have been in it, have been killed, or severely injured, whilst those in the next carriages have either escaped, or been less injured. Hence the expedient of placing an empty carriage of some sort next to the tender has been generally, and I think justly, deemed conducive to safety. A truck, loaded with hard materials, such as iron, stone, &c., placed next to the tender, might, on the contrary, do infinitely more harm than good. It has been suggested that a peculiar carriage, with more powerful buffer-springs, or, as it were, all buffer-springs, would be desirable, instead of a common carriage, and I believe so; but it is still more important to adopt such measures as shall do away with the risk of locomotive engines breaking down, or being suddenly stopped by some obstacle capable of producing that effect.

4. *Slips in cuttings and embankments.*

These have invariably arisen from the slopes having originally been made too steep, perhaps for want of experience on the part of railway engineers, who had, as it were, to create a new art, for they have never in the first instance allowed a slope of more than two to one, even in the worst descriptions of soil, which I should myself, when new to the subject, have considered ample; but from subsequent experience and observation, I am of opinion that, in all deep cuttings in plastic clay, slopes of four to one on one side, and of three to one on the other, ought to have been allowed; for, though both sides are liable to slip in such soil, yet one side is usually more exposed to this injurious action than the other, owing to the inclination of the strata. But it may be doubted whether, in all cases, inexperience on the part of railway engineers could have been the cause of their adopting insufficient slopes; because, in Sir Henry Parnell's book on road-making, published so far back as 1833, it is laid down as one of the rules, &c., professedly derived from the practice and experience of the late eminent civil engineer, Mr. Telford, that in the London and plastic clay formations, it will not be safe to make the slopes of embankments, or cuttings, that exceed four feet in height, with a steeper slope than three to one. As most of the great railways have been executed since that period, in some of which the depths of cuttings are from 15 or 20, and even 70, feet, and the heights of embankments also very considerable, a query occurs, whether inexperience could have been altogether the cause of neglecting so salutary a maxim. May not, in

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to a new railway, have caused a steep slope to have been adopted in preference to a flatter one, because the latter would have made the estimated expense of the removal of earth much greater? However that may be, experience has shown that, after embankments have once come to their bearings, slips are not to be so much apprehended as in deep cuttings. In the latter, laid out, as before observed, with slopes not exceeding two to one, experience has proved that slips must be expected for years after the opening of the railway. The repeated slips on both sides of the Croydon Railway, for example, took place nearly two years, and that on the west side of the Bugbook cutting, on the London and Birmingham Railway, more than four years, after these lines had been opened; and in both cases, notwithstanding that both lines of rails were completely buried by the immense masses of earth thrown down, yet no danger to passengers resulted, owing to these cuttings having fortunately been carefully watched. This precaution, therefore, of continued and careful watching, is absolutely necessary, in respect to embankments and cuttings in plastic clay, especially the latter; for, if not discovered in time, a very insignificant slip of earth from one of the sides of a cutting, though capable of being removed in a few hours, might, by suddenly stopping an engine at full speed, endanger the lives of the passengers in the carriages nearest to the tender—an instance of which actually occurred on a different railway about a year ago. But if the state of cuttings and embankments be always carefully attended to, no serious accident is to be apprehended from any slip, however considerable. I shall only further observe, that it is well known that not merely the nature of the slopes, but also the proper drainage of cuttings and embankments, are essential considerations, both in preventing slips in the first instance, as well as the repetition of them in unfavorable soil.

5. *Of the axles and wheels of railway carriages.*

The breaking of an axle of a locomotive engine is, I believe, more common than the public generally suppose, and, though seldom fatal, it sometimes may be so, as in the case of the accident of the 8th inst. on the London and Birmingham Railway; and though the fracture of an axle of one of their four-wheeled locomotive engines, in that peculiarly dangerous manner, has only occurred once in six years, yet, admitting the possibility of a precisely similar fracture of any of their axles occurring again, the same result must inevitably follow; but I see no mode of guarding against it in four-wheeled locomotive engines with inside bearings, except by adding a light outside framing on each side, which need not have regular brasses like those attached to the present inside frame, nor need they act upon the axle when the engine is in a perfect state; but, though not in contact with it, they should be so near as to come into play whenever the axle breaks. By this arrangement, the wheels would not be able to get away under any circumstances. I have seen a similar arrangement adopted on the South Western Railway, in respect to the fore axle of one

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John V. Gooch, their superintendent of the locomotive department, who has attached horns, as they are technically termed, inside of the wheels, ready to act should the axle break, but not otherwise; a precaution, however, which, though it may be prudent, is not absolutely necessary in the six-wheeled engine. I have also seen the crank axle, or centre axle, of a six-wheeled engine made with double bearings, springs, and brasses, both in one of Mr. Robert Stephenson's old engines, and in one at the South Western Railway, and also in Sir John and Mr. George Rennie's new engines; but, on the whole, after having carefully considered this subject, I came to a conclusion that six-wheeled engines, with outside bearings for the fore and hind axles, and with inside bearings for the crank axle, would be a convenient and sufficiently safe arrangement, especially if horns of the description before mentioned be used as a sort of guard for the fore axles in the event of a fracture. After having formed this opinion, I was informed that Mr. Gray, of the Hull and Selby Railway, whose engines I have not yet seen, had previously adopted and actually carried it into effect. Under these impressions, I do not think that Mr. Robert Stephenson has made a change for the better in his new patent six-wheeled engines, in which he has adopted inside bearings for all his axles. I also consider the want of flanches on his centre wheels (which is a peculiarity in that gentleman's engines) to be rather a defect than otherwise.

6. *Hollow axles, &c.*

The axles of the engines and carriages of railways are usually tested in a manner more or less severe, and those which fail are rejected; but it is believed that, though good at first, they become deteriorated in time, not merely by wear, but that the metal gradually loses the proper fibrous texture of malleable iron, and becomes crystalized and brittle like cast iron. Besides magnetic influence between the brass journals and the iron, which has by some been considered the chief cause of this deterioration, the axles of railway engines, &c., are liable to two sorts of injurious action; first, the jolting or jumping at high speed, owing to little inequalities in the rails, which is equivalent to cold hammering; secondly, to torsion in going round curves, or otherwise. In traveling upon six-wheeled and on four-wheeled engines, I have found the former generally smoother, so that the action of percussion appears to me to act with greater violence on the axles of the latter. Mr. John Oliver York has recently taken out a patent for hollow axles, in which only two semicircular plates of malleable iron are welded together, instead of a great number of bars being united by the same process, to form a solid axle, according to the usual custom. His opinion is, that it is the original welding chiefly that injures the iron; but whether his theory be correct or not, I have been informed that, on comparing his hollow axles, of 4 inches exterior diameter, with solid axles of 3½ inches diameter, by subjecting both to the blows of a 38 lb. hammer, the former were found to possess much greater resistance, though containing rather less iron. If the

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hollow axle should show the same superiority over the solid one, in its resistance to torsion, as it has evinced in respect to percussion, (an experiment which is about to be tried at the Camden Town station of the London and Birmingham Railway, at the suggestion of Mr. Bury, who considers the former to be the most injurious action of the two,) I think it probable that hollow axles will generally be adopted by all railway companies, as soon as their present solid axles shall require to be replaced by new, which must of course be done sooner or later. In respect to the working, or cranked, axles of locomotive engines, the hollow pattern is entirely inapplicable, but it may be used for all the other axles of locomotives, and all the axles of tenders, carriages, wagons, and trucks upon railways, without exception; and, upon the whole, I consider it very promising.

7. *Of railway signals.*

These are nearly assimilated on all the railways that I have inspected; the red color, or light, being the signal of danger, requiring a train to stop, and the green being the signal of caution; but in some railways, the red light in the rear of the hind carriage of a train is placed so low that it may be obscured by some intervening object, and consequently not seen by the engineman of another train, or of a special engine, following, which was the cause of a collision on the Croydon railway. It is therefore desirable that all railway companies should adopt the system, of which the principal ones have already shown an example, by placing on the hind carriage of every train two red lights, one on each side, so high that they cannot be obscured; and, on the lines alluded to, the low central red light has also been retained, though less necessary. In fogs, a red light is sent out from a station to a sufficient distance to warn the coming trains to slacken their speed; and in the case of a train breaking down, or being obliged to stop, at some intermediate point between two stations, a man is sent back with a red light as a warning to the next coming train to stop, in order to prevent collision. On the London and Birmingham railway, a very ingenious plan has lately been adopted in case of fog, or danger; that is, to send a man to place a small tin box, containing a charge of gunpowder, with a little fulminating powder, on the line of rails by which the next train is advancing; as soon as the wheel of the locomotive engine of which passes over this box, it fires the charge, with an explosion sufficiently loud to be heard in the most stormy night, but not powerful enough to injure the rails, or engine. Under the circumstances supposed, this arrangement, as a night signal of danger or caution, is evidently preferable to a red light, because no neglect or inattention on the part of the engineman, stoker, &c., can render it possible for them to pass on without being aware of the explosion, which can never fail to take place; but the combination of both might, perhaps, be still better than either of these expedients singly.

8. *Of untried inventions for preventing accidents on railways.*

A great number of plans of alleged improvements in railway engines, carriages, and signals, and in the rails, switches, &c. &c., with

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a view to safety, as also for preventing slips in cuttings and embankments, have been brought under my notice in the course of the present year, (many of them extremely ingenious, but some very complicated,) by their respective inventors, to whom I have invariably returned the same answer, namely, that I shall be happy to see their inventions, for the sake of personal information, but that I decline recommending them, or even giving an opinion upon them, as the adoption of such plans must depend entirely upon the directors of railway companies, upon whom the Board of Trade will not urge any experimental arrangements involving expense.—I have, &c.,

C. W. Pasley, Major General,
and Inspector General of Railways.

The Right Hon. the Earl of Ripon, &c. &c. Railway Mag.

On the Mode of Calculating the Strength of Cylindrical Steam Boilers. By B. H. Latrobe, C. E.

To the Committee on Publications:

Gentlemen—In the January number of the Journal is an article by Thos. W. Bakewell, Esq., in which the memoir of the explosion of the steamboat Medora, prepared by me at your request, and published in November last, is referred to as "another instance of respectable authority to a prevailing and dangerous error in estimating the capabilities of cylindrical boilers to sustain a given pressure of steam." I have read Mr. Bakewell's remarks with respectful attention, and a desire to discover the error (if any) which he alleges to exist in the mode of computation which I had adopted, and for the truth of which, as he acknowledges it to be the "received rule," I can be under no special responsibility. I am unable, however, to perceive wherein lies the supposed mistake in the formula which I used, and which is expressed by the equation $x = \frac{2Pt}{D}$; where P is the cohesive force of the metal of the boiler per square inch—t, the thickness of the shell in inches—D, the diameter of the boiler, also in inches—and x the extreme pressure, per square inch, that it will bear. I now offer the following remarks as expressing my confirmed conviction, with the reasons therefor, that the rule is right, Mr. Bakewell's belief to the contrary notwithstanding.

Let us look into the conditions of the question. In what manner does an elastic fluid, pressing equally in every direction within a hollow cylinder, act to produce its rupture? Plainly by tending, in the first instance, to drive before it, in a radial direction, perpendicular to the surface of the cylinder at any point which may be selected, each particle, or rather line of particles, forming its thickness at that point. This is the primary action of the pressure upon each individual atom of the shell. But it is manifest that the forces tending to separate any two of those atoms contiguous to each other, are not identically those just named, but a *resultant* from them; for they themselves operate

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on those two adjacent particles, in lines making so small an angle with each other as to be, in effect, parallel; so that the particles would be driven off side by side, instead of pursuing opposite directions, as they in fact do in the case of fracture. Moreover, how small soever this angle may be supposed, inclosing, as it is assumed to do, only the breadth of an atom at the periphery of the cylinder, it will, in embracing the same atom, increase its opening as the radii diminish; so that, if the particle were torn asunder directly by these very radial forces, their action would obviously become more powerful as the diameter of the cylinder lessened, which is in opposition to the admitted fact that, the less the diameter, the *greater* the strength, of the vessel. What, then, is the resultant of these radial forces which has just been referred to, and of which we are in search? In seeking an answer to this question, we must bear in mind that, in tearing a body of any kind asunder, two forces, in some degree superior to its cohesion, must be exercised upon it in *opposite* directions; otherwise (unless the two were in exact equilibrium) it would move *bodily* in the direction of the greater force. The two halves of the cylinder in question are thus urged with equal energy, by the outward pressure of the fluid, towards opposite quarters, and we have only to consider the strains to which the shell is subjected at the two ends of any one of its diameters. Now, these strains are equal to the sum of those of the components of all the radial forces on the semicircumference which act tangentially to the cylinder at the points strained, and they are to be estimated by multiplying the unit of pressure by the *diameter;* for the sum of the radial pressures being represented by the semicircumference to which they are perpendicular, the diameter will represent the sum of those perpendicular to itself, and the radius that of those parallel thereto, according to the parallelogram of forces—each radial line of pressure being resolved into one parallel to the diameter, and unproductive of effect upon the parts strained, because its direction is at right angles to that in which they must move in separating, and the other perpendicular to the diameter, and productive of motion in the particles subjected to the stress, because its direction is the same that they would severally take in parting from each other. It is, indeed, most manifest, without the aid of rigorous mathematical demonstration, that no force, oblique to the direction pursued by the body to which it is applied, can operate with its full intensity upon that body, but must expend a portion of its energy upon some other object. Mr. Bakewell's error seems to me to consist in losing sight of this elementary truth, for, in using the semicircumference instead of the diameter in his estimate of the pressure at the extremities of the latter, he omits the resolution of the radial forces into their operative and inoperative elements, and assumes them to act with their full intensity to tear the cylinder asunder, notwithstanding the greater, or lesser, obliquity of every one of them, excepting the single central one perpendicular to the diameter. But, it may be said, what becomes of the other components of these radial forces, which act *parallel* to the diameter in question? Are they to be lost sight of, and do they produce no increase of strain upon the points

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der does sustain from them a stress at the ends of the diameter," in the disadvantageous manner of a string stretched horizontally, and bearing weight." They are certainly not to be forgotten, though as surely do they produce no such increase of strain. For, in the first place, it must be borne in mind that the body under consideration is a *cylinder*, every point of whose circumference is like all the rest, and that the two points in question, at the ends of any one of the infinite number of diameters, are supposed, for the time being, to be the *peculiar* seats of the stress, only for the sake of the argument and its illustration,—that all other points of the cylinder are precisely alike in their positions and functions. The central line of pressure just mentioned as perpendicular to the assumed diameter, and as producing the maximum of all the radial strains when they are referred to that diameter, is itself a part of a diameter which may, in its turn, become the subject of a similar assumption, and, when it does so, becomes the line of *least* (as it was before of *greatest*) pressure—that is, the line of no pressure at all. In the second place, the *parallel* unite with the *perpendicular* components of the radial forces to give the cylinder the *stiffness*, the supposed want of which is a main difficulty with Mr. B. It is the uniform tension of the steam which gives the required rigidity to the cylindrical vessel, however flexible its material; and if it were of gold leaf, or gossamer, it would still be perfectly stiff for the purpose in view, for its shape would continue *unaltered up to the moment of rupture;* and this preservation of form is all that absolute inflexibility in the shell, *per se*, could accomplish.

I have thus far argued the case upon the simple elementary principles which seem to me to govern it. I might proceed to give an analytical, or geometrical, solution of it, accompanied by diagrams; but as this would extend my communication beyond desirable limits, I will refer, instead, to the brief but satisfactory demonstration of Professor Barlow, in the part of his work upon the "Strength of Materials," under the head of "Strength of hydraulic presses and water pipes," (pages 205 to 210, London edition.) This well known treatise is probably accessible to most of your professional readers. It will be seen therein that the learned Professor upholds the received rule, and makes no mention of the existence of a doubt of its accuracy, among scientific men. It is true, he shows that, in consequence of the difference between the interior and exterior diameters of every hollow cylinder, the strain is not uniform throughout the thickness of the shell, but diminishes regularly from the inside to the outside thereof—so that, by the law "ut tensio sic vis," the metal being unequally strained in different parts of its section, the full resistance of all the fibres is not brought into action at the same moment; so that a deduction from the *actual*, in the calculation of the *effective*, thickness, is due to this cause. But the correction, on this account, for cylinders of large diameter, is so trifling, that it need not be considered in the present controversy. Thus, where r represents the (internal) radius, and t the actual thickness of the shell of the cylinder, the *effective*

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thickness is expressed by $t \times \frac{r}{r+t}$; which, in the case of a boiler of 132 inches diameter, like the Medora's, would make the effective only 0.0061 of an inch (or about 2½ per cent.) less than the actual thickness, the latter being one-fourth of an inch.

The example by which Mr. B. illustrates his views of the theory of strength in a cylinder, although ingenious, seems to me inapplicable to the case, because it is inconsistent with the essential characteristic of the vessel, viz., its equality of resistance everywhere, resulting from the circularity of its form. It is not then allowable, even in argument, to suppose it to be cut at any point, and the cohesion (thus destroyed) of the material composing the shell to be represented by bolts acting as ties, unless we suppose those ties to take hold, not, according to Mr. B.'s supposition, of only two, or four, or more, insulated points, but of *every point of the periphery;* in which case, the argument drawn from the want of *stiffness* would fail, and the vessel would be, in effect, restored to its pristine condition of an undivided hollow body, equally strong everywhere; so that the reasoning would be as circular as the cylinder, and would come back by as roundabout a course to its point of departure.

It is necessary to use these hypothetical modes of reasoning with caution; nevertheless, I will offer an illustrative instance, which, I think, will make more clear the correctness of the positions already established upon abstract principles. Suppose that, instead of steam within the cylinder, (which, as Mr. B. has done, I will imagine to be a ring of an inch in width, and, consequently, giving a square inch for every inch in the length of its periphery,) we should introduce a solid disk of some hard body, fitting close against the interior of the ring. Let us then divide this disk into two equal parts, by cutting it through, on one of its diameters; let us further introduce a wedge between the halves, and force them apart by a power equal to that of steam of any given pressure, operating on the number of square inches contained in the length of the diameter—or, better still, let us introduce steam itself into the fissure, so that the two sections of the plate are forced asunder in directions perpendicular to the line of separation. The space between them need not be more than a hair's breadth to permit the full action of the fluid. Consequently, its pressure upon the ring at the ends of the opening will be on a mere line an inch long, and will produce no appreciable strain at those places. The only tension felt thereat will then be perpendicular to the line of the opening, and strictly tangential to the curve, and will be expressed by the number of inches in the diameter multiplied by the steam pressure per square inch. The ring might, indeed, give way indifferently at any point of its circumference, were it not that it has, at all other points than those at which the disk is cut, the benefit of its *friction* upon the latter. Will it now be contended that the strain upon the cylinder would be increased if the disk were removed, and the office it performs (of preserving the shape of the ring) be effected by the equal radial pressures of the steam?

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Such are the conditions of the question as it presents itself to my mind; and they seem to me to consist with the established mode of computing the strength of cylindrical vessels, and with that only. As the elementary facts and principles on which such questions depend are often, however, far from being so obvious as to make the same impressions upon every mind, but, on the contrary, are frequently of so subtle and recondite a character as to elude the grasp of the inquirer, and are perhaps so in this instance, I would not dogmatically aver that the preceding exposition of the subject is sound beyond the possibility of a flaw. I would be glad that the matter should meet the consideration of others competent to its investigation. The question is a most important one, and has not, perhaps, been sufficiently discussed; at least, I do not at this moment recollect any elementary work in which it is treated of, except the brief notice of it by Professor Barlow, above quoted. It is time it should be finally settled by all the arguments and authorities which may be brought to bear upon it. If the rule heretofore used has indeed given results so much too favorable to the strength of steam boilers as Mr. Bakewell supposes, then the risks from which a watchful Providence has so often preserved those who have to do with them, have been far greater than we have been aware of; and while we feel increased thankfulness for past protection from these perils, we should not be unmindful to guard against them more effectually hereafter.

I have above considered only the effects, upon a hollow cylinder, of the *radial* stress of the confined fluid resolved into two resultants perpendicular to, and acting at the ends of, the diameter. The longitudinal strain parallel to the axis of the vessel has not been taken into view, for it is not clear that it, in fact, augments the tensile effect of the radial strain. It is not necessary, however, to discuss this question at present, and I therefore waive it.

In conclusion, permit me, gentlemen, (in reference to the catastrophe which led to this discussion,) to express the pleasure with which I perused, in your last number, the corrected calculations of the stress and strength of the boiler of the Medora, contained in an article prepared from particulars lately furnished by Mr. Reeder, who rebuilt the boiler after its explosion, and whose opportunities of acquaintance with all the details of its structure were much more perfect than my own, and were judiciously availed of by him, and their results lucidly presented by yourselves. BENJ. H. LATROBE, Civ. Eng.

Baltimore, May 18, 1843.

Remarks on the Explosion of the Boiler of the Steamboat Mohegan, on Long Island Sound. By THOMAS EWBANK, *Esq.*

To the Committee on Publications:

GENTLEMEN—An explosion occurred in one of the boilers of the steamboat "Mohegan," on the 24th ultimo. It was so slightly noticed by the daily press, and so trivial a character given to it, that no manifestation of feeling disturbed the public mind. At first I supposed

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it hardly worth while to inquire into the particulars, or to trouble you with them; but, subsequently, taking up a paper which (after briefly noticing the affair) naively remarked that it was only occasioned by "a few sheets" having "slipped off the outside of the boiler," it became evident that the rupture was no trifling one. If a very small rent in a boiler be often sufficient to spread desolation over every part of a vessel, how much more the sudden displacement of whole sheets! Upon visiting the boat and examining the boiler, the conviction was irresistible, that, but for a fortuitous and apparently insignificant circumstance, this explosion would, in all probability, have been the most fatal on record.

Through the politeness of C. O. Handy, Esq., (President of the company by whom the boat is owned,) I am enabled to communicate every essential fact connected with the explosion, and also two strips from the sheet in which the rupture commenced. Let me premise the account with a few remarks, which, if they have no particular reference to the case of the Mohegan, have at least been elicited by circumstances connected with the present investigation.

It is gratifying to observe the jealousy and opposition dying away with which inquiries into explosions were used to be met, on the part of owners and officers. Ere long those gentlemen will, it is believed, generally acknowledge that such researches are of real value to themselves, not only as pointing out the true causes of explosions, the means of preventing them, and the enormous losses consequent on them, but as also contributing to remove doubt and suspicion from the public mind. People can have no confidence in traveling by steam while these disasters are so sedulously hushed up—while the causes of them are pronounced too mysterious to be meddled with—too occult to be explained.

As long as such sentiments are cultivated, people will naturally, and reasonably too, consider steamers as little else than floating volcanoes; and the boldest travelers will have secret misgivings when confined to the vicinity of boilers. Where there is uncertainty, there must be suspicion, or fear; but let the origin of explosions be made known—let people be convinced that there is no more mystery in the rupture of boilers, than in the breaking of a carriage axle, or the oversetting of a wagon, and that they may as certainly be avoided, and all dread of traveling by steam will become dissipated like a morning cloud.

Steam is destined to be the grand physical agent of man—to supersede animal and human drudgery, in a great measure, throughout the whole earth. Every person is therefore interested in its extension—the social, civil, and mental improvements of our race, are bound up with this plastic and powerful agent—all people in coming ages will be influenced, nay, moulded, by it. As a motive fluid, its blessings will be felt (like those of the atmosphere) over every part of our planet. Away, then, with the contracted ideas of those who look upon inquiries into explosions as interfering with their peculiar professions—as prying into subjects exclusively their own. Nothing can retard the universal adoption of steam as a first mover, so much as

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those unworthy prejudices. Had such objections been always listened to, where there are now a hundred steam engines and steam vessels, there would not have been ten. The plea that inquiry tends to inflame, instead of to allay people's fears, is supremely absurd. The reverse ever has been, and must be, the case, no matter what the subject of inquiry may be.

But it is said, "Why inquire into steamboat explosions after they are over? The evil is then done, and cannot be undone. Inquiry can only end in blaming somebody, and perhaps without cause." Certainly these disasters cannot be scrutinized until they have occurred, no more than a boiler can be examined before it be made; nor can the calamities attending explosions be recalled. But, by critical examinations, similar evils may be prevented in future, and this is the legitimate object of inquiry. As for tracing the blame to 'somebody,' that may or may not be; but it is quite a secondary matter. It is well known, however, that the blame is often, and always unjustly, fastened upon "something." In some explosions, we are told the fault was in the feed pump—in others, the material of the boilers was defective—in others the flues, or the stay bolts, had given way. In some, the water, the fire, or the steam, &c., was the cause; as if there were neglect, inadvertence, waywardness, or deception, in these. They are the faithful slaves of man, ever attentive to the intelligent hand that controls them; and should they be abused for this? abused for invariably obeying the mandates of him whose power compels their obedience?

A feed-pump, like every other machine, always acts as its overseer wills it; that is, as he keeps it in working order, or not. Aqueous vapor will not accumulate in a boiler unless compeled to do so, nor can the flue and shell be rent asunder of their own accord. Is it the fault of a pump that it ceases to work? of the vapor, that its tension dangerously increases? or of the metal, that its texture and condition cannot resist the pressure brought to bear upon it? An unfeeling man overworks his horse till the animal dies from exhaustion: what would be thought of him, if, to exculpate himself, he laid the blame on the load? So, a boiler is overloaded with steam, and destroyed, but few think of laying the blame anywhere but on itself; as if *it* was to blame, or was expected to give warning of its condition—to betray its sufferings, like an animal, ere it expired. True, sometimes a boiler does so; but too generally it gives up the ghost in one unexpected and convulsive shudder.

A passenger in the street is knocked down by a ladder borne by two laborers behind him: what would be his surprise to find his remonstrance met by an assertion that the cause of his distress was in the ladder, and not in those who bore it? A person stumbles in the dark over a bucket, or breaks his head against a low beam: would it be wise to indict the one, or to call down negative blessings on the other? Now, something like this has been the way by which the works of man's hands have been blamed for his own forgetfulness, or neglect. Every material and every machine act by invariable laws;

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and whenever they exceed in any respect the limits assigned them, it is because those limits have been removed. But enough.

The Mohegan is one of the regular line of steamers which navigate the Sound between this city and Stonington. She is 180 feet long, 25 feet beam, 9½ feet in the hold, and propelled by a low pressure engine, the cylinder of which is 42 inches diameter, and the range of the piston 11 feet. The motive fluid was furnished by two boilers, alike in all respects, and similar in construction to those adopted in locomotive carriages. They are of copper, one-fourth of an inch thick nearly, or No. 4 wire gauge, and were new about four years ago, when the boat was built. They were placed fore and aft, on the guards.

The accompanying figures will convey a correct idea of the construction of the exploded boiler, and the location and extent of the rent. The cylindrical part, or shell, A, is 7 feet in diameter, and 10 feet long. The fire chamber B is 6½ feet, making the entire boiler 16½ feet in length. There are two separate fireplaces, a water-leg forming a partition between them. The interior tubes (also copper) are 3 inches diameter, and occupy about two-thirds of the shell. The ends of the cylindrical shell are connected to each other by bolts riveted to them, and also by rods passing through several of the tubes. The ends are also united by bars to the sides, but there are no transverse stay-bars.

The engineer appointed soon after the boat was built, remained in charge till a few weeks before the explosion. He generally used steam of 25 lbs. to the inch, and is said rarely to have exceeded 30 lbs. The latter was considered within the limits of safety, though certainly verging towards those of danger. It exceeds the amount that a copper boiler of such a diameter ought to have been subjected to, according to the ordinary mode of calculation. From the comparatively large extent of fire surface, the evolution of steam was very rapid; and from the small space in the boilers for storing it, (small compared to the dimensions of the working cylinder,) particular care was required to prevent its undue accumulation. When the vessel was underweigh, the feed-pump was necessarily in almost constant requisition. It was not safe to allow it to remain many minutes unemployed. On account of excessive foaming, considerable experience with the boilers was necessary before a person could be certain of the height of the water within them. Oil was used to diminish the foaming. Wood was the fuel used.

The Mohegan left her berth in this city at 5, P. M., with 150 passengers. While passing through Hurlgate, the steam was turned off from the engine twice, in consequence of vessels crossing her path. The engineer states that he raised the safety valve on both occasions, and that it was while in the act of closing it, the explosion took place. Providentially, the rupture was in the starboard side of the starboard boiler, so that the contents, after blowing away the adjoining bulwarks, escaped overboard. Had the rent occurred on the opposite side of the boiler, the results must have been awfully appalling, as few of the passengers were below. Two or three persons were

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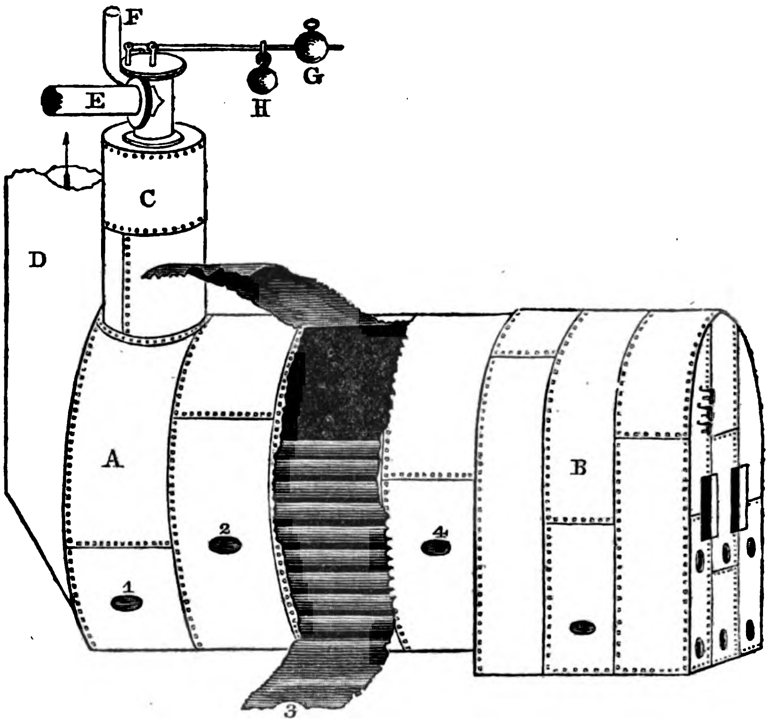

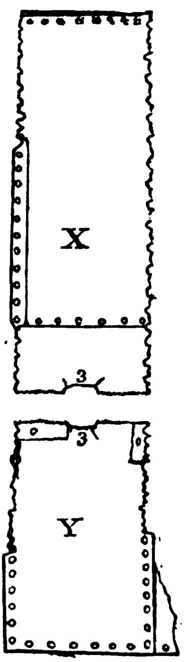

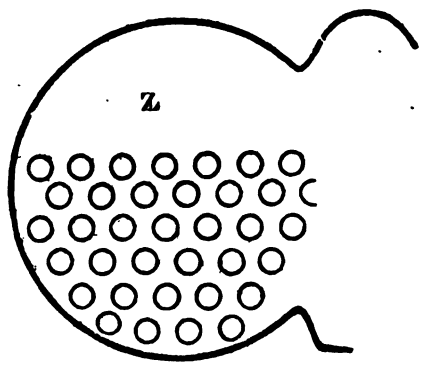

A, cylindrical shell of boiler, showing the part ruptured, and a portion of the interior smoke pipes, or flues.
B, fire chamber. C, steam dome. D, chimney.
E, steam pipe. F, waste steam pipe and safety valve.
1, 2, 3, 4, elliptic hand-holes in the shell, at one of which (3) the rupture commenced.
G, stationary weight on the lever of the valve.
H, movable weight.
X, Y, ruptured sheets.
Z, transverse section of boiler at place of rupture.

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boat, and none to the engine. The boiler was started by the recoil two feet, but was not overturned, nor the chimney pipe displaced. Both boilers have been removed, and will be replaced by a single one of iron, in which coal, instead of wood, will be used.

Several elliptic "hand-holes" were made in different parts of the boilers; there were four on each side of the cylindrical shell A, and arranged as seen in the figure. They are all of one size, viz., 6¾ by 4 inches. They were not originally formed in the boilers, but were made about two years ago, when the boat lay in Providence. Their edges are not strengthened in any way, but are plain and smooth, as the chisel that cut out the removed pieces, and the file, left them—an oversight, since the boilers were essentially weakened by them. Some precautions should have been taken to render the parts equally strong as before; a strong rim, or border, riveted round each hole, was necessary, as well to stiffen it, as to prevent the effects of checks, or notches, left by the chisel.

The utility of this will soon be apparent to the reader, if it be not already. The removal of the pieces cut from so large a copper shell, obviously rendered the borders of the openings incomparably weaker than any other part, and the interior covers made them still weaker, or, at least, had a tendency to do so. These covers lapped over them an inch, and were secured in the usual way; but it is obvious they transmitted to the borders of the openings the whole pressure to which they themselves were subjected. Thus, while the borders were less able to resist the force of steam than before the openings were made, a much greater one was accumulated through the covers upon them. Had the boilers been small cylinders of iron, the case would have been very different; but with comparatively soft and yielding copper, the action of the covers was not much unlike that of conical plugs, forced into openings to swell out their sides. Had the "hand-holes" been thus secured, the expense would have been trifling, and the boat might still have been running. With the exception of these "holes," with which the makers of the boilers had nothing to do, no defect whatever was to be found in their fabrication.

The rupture commenced near the bottom of A, at the hand-hole marked 3; this was in a line with 1. The rent was in the direction of the longer axis of the hole, separating the sheet, through its entire width, in nearly a straight line. The lower portion was blown outwards, and ripped from the adjoining sheets, on both sides, down to the deck; the upper one was torn, in like manner, from the neighboring seams, and thrown up to the roof of the boiler. See figures.

As the part of the boiler rent was cylindrical, of which no part was exposed to the fire, or to be otherwise deteriorated, it may be asked, What induced the rupture to commence where it did, in preference to any other place? Of course there was some cause for its beginning there? The circumstance alluded to at the close of the first paragraph, affords an answer to the question. A *crack* had long existed on each end of the hand-hole 3; one was an inch long, and the other rather more. These were noticed soon after the boat returned to the

city, and were distinguished from the parts newly rent by having fragments of red lead on them, and which had doubtless been squeezed in from the gasket of the cover. I had an opportunity of examining them, and have now a small fragment of copper exhibiting one side of the shorter crack.

Both cracks were probably made by the workman who formed the opening. In driving out the displaced piece of metal, after making an indentation round it with the chisel, it had become *torn* in those places to the extent named; and, from the exceeding brittleness of the copper, this is not surprising. They had been closed carefully up, and were not afterwards very observable, if at all. These cracks, then, or rather rents, determined the place of the rupture, and gave the first direction to it. And it was fortunate that they did, considering the position of the opening (3) with regard to the boat and deck. The rents, or cracks, acted the part of a safety valve, and gave to the rushing fluid the safest of all directions. Other cracks are still to be seen on the borders of the hole, (see the ruptured sheets X Y,) but whether they were there previous to the explosion, is not known.

A deficiency of water has been suggested as an approximate cause of this explosion, but without any facts, I think, upon which to base it. It is said that, when the engine was at work, no deficiency could be detected on account of the foaming; but when the steam was shut off the last time at Hurlgate, the water would immediately sink to its level, and leave the dome of the fireplace *bare;* the dome would instantly be heated to redness, and, when the foaming again covered it with water, on the renewed action of the engine, such dense volumes of vapor were suddenly generated, that the boiler was unable to confine them.

One conclusive objection to this hypothesis is—had the fire dome even been heated to incandescence, as supposed, it must have been, beyond comparison, the weakest part of the boiler, and must, while so heated, have given way. Another is, the captain and engineers declare that the engine was never wholly stópped at the gate—its speed was only slackened, and hence the foaming could never have entirely ceased. A third is, there is no indication of any part of the boiler having been injured by the fire.

Generally speaking, there is but one opinion respecting the immediate cause of this explosion, viz., an excessive accumulation of steam. This was probably only temporary, and occasioned by the partial stoppage of the boat immediately previous. The engineer asserts that there was no more than 20 lbs. of steam at the moment of rupture, and he is considered both cautious and intelligent. Though recently appointed to the Mohegan, he has been in the company's service several years. He usually carried steam of from 22 to 24 lbs. When the boat returned to the city, two weights were observed on the lever of the safety valve, (see figure,) one of which was reported to be an extra one; but this was not correct. Both weights had always been used—a stationary one, G, and the smaller one, H, used occasionally. Both were on the lever at the time of the explosion, the smaller one "about midway" between the end of the lever and the valve. In re-

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when the lever was loaded with one, or both, weights? the answer was—with both, 23 to 24 lbs.; with the stationary weight only, from 17 to 18 lbs.

With the permission of Mr. H., the following data for determining the force required to raise the valve with one or both weights, were procured. The diameter of the underside of the safety valves is six inches, giving an area of 28.2 inches. The lever is a bar of iron, half an inch thick; at one end, three inches deep, at the other, one and a half. The distance between the centre of the fulcrum and that of the valve, 4¾ inches. The weight G was stationed 54½ inches from the valve; it is a ball of iron, with an opening through its centre to slide over the lever, and a screw to fasten it in its place. Though not on the lever when examined, its place was strongly defined. It weighed 52 lbs. The weight H was suspended by a hook, or S, so as to be readily attached to any part of the lever; it weighed 28 lbs.

The pressure which the lever alone exerted on the valve, was 164 lbs. Then $52 \times 11\frac{1}{2}$ (the distance between the valve and G, divided by that between the valve and fulcrum,) $+ 164 = 762$ lbs., the aggregate load on the valve with the stationary weight only. This, divided by 28.2, gives rising 27 lbs. on the inch; but add 180 lbs. for the weight H, and the force required to raise the valve could not have been less than 33 lbs., exclusive of friction, and that adhesion to which valves, it is well known, are subject.

The load on the valve, when not overcome by the steam, is, however, no criterion of the tension of the vapor at the instant of explosion. Of this, the gauge was the true and only test; and if the eye of the engineer was upon it immediately preceding the rupture, his statement that only 20 lbs. were on (if he was not mistaken) must be received. But the question then occurs—how is it that the shell of the boiler should have given way at 20 lbs., when, under the same circumstances, it has withstood steam at quite, or nearly, 40 lbs.? To this it has been replied—"The cracks where the rupture began had probably been strained, or started, and hence gave way with the lesser force." This is very unsatisfactory, for, if they had been strained, they would have leaked; but admit they did not—if steam, of an expansive force equivalent to 35 or 40 lbs. the inch, ever *started* the cracks at all, they must have been instantaneously rent wide asunder, for they were weaker when started than the moment before; and even a less force could then continue the rent than the one which commenced it.

It cannot, I think, be questioned, that part of the sheets which form the shell of the boiler, are of very inferior copper. The metal is so exceedingly brittle, that a single blow of a hammer has broken off portions as readily as if it had been bell-metal. Even pieces an inch square, on being laid over a hollow place, have snapped in two as if they had been spelter. Either the metal is deeply alloyed, or has been overheated in its manufacture, or else extremely hard rolled, though how the last operation could make its grain so short, is difficult to perceive. No responsibility could, however, in either case, be

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metal.

The specimens sent are from the sheet Y, and taken from the line of rupture. One piece is cut out in the direction in which the metal was rolled—i. e. the lengthways of the sheet—and the other in the opposite one. The places whence they were taken, are marked *o o*, on the upper part of Y. All the rents present the edges short and clean, almost as if cut with shears. The direction of the rents, with regard to the seams and rivets, is sufficiently obvious in the figures.

New York, May 1, 1843. T. E.

Statistics of fifty-four Passages (each way) of the "Great Western" across the Atlantic, between the years 1838 *and* 1842. *Time by the Chronometer.*

From Bristol, or Liverpool, to New York, viz., from Kingroad, or the Docks, to the Wharf.

Sailed.	Arrived.	Time. d.	Time. h.	Yearly av'ge time of trip. d.	Yearly av'ge time of trip. h.	Dist. run in naut. miles.	Passengers.	Yearly av. of passengers per trip.
April 8, 1838,	April 23, 1838,	15	10			3111	7	
June 2,	June 17,	14	16			3140	57	
July 21,	August 5,	14	18			3043	131	
September 8,	September 24,	16	9			3050	143	
October 27,	November 15,	19	0	16	1½	3100	107	89.
January 28, 1839,	February 16, 1839,	18	20			3114	104	
March 23,	April 14,	22	6			3350	110	
May 18,	May 31,	13	12			3086	107	
July 6,	July 22,	16	0			3030	114	
August 24,	September 10,	16	20			3025	113	
October 19,	November 2,	14	22	17	1½	3021	137	114.1
February 20, 1840,	March 7, 1840,	15	17			3058	77	
April 15,	May 3,	17	20			3093	100	
June 4,	June 18,	14	18			3073	85	
July 25,	August 9,	14	23			3018	97	
September 12,	September 27,	15	7			3049	54	
November 7,	November 24,	16	12	15	20	3025	40	75.3
April 8, 1841,	April 23, 1841,	15	12*			3096	44	
May 27,	June 10,	14	12			3033	42	
July 14,	July 29,	15	2			3014	98	
September 1,	September 16,	15	10			3036	111	
October 23, 1 15 P.M.	November 8, midnight,	16	12	15	9½	3035	127	84.2
April 2, 1842, 1 30 P.M.	April 17, noon,	15	4			3093	69	
May 21, 5 P.M.	June 4, 2 25 P.M.	14	2½			3020	64	
July 16, 1 P.M.	July 30,	14	1½			3028	65	
September 3, 5 P.M.	September 17, 10 P.M.	14	10			3020	97	
October 22, 3 P.M.	November 6, 6½ P.M.	15	8	14	15	3036	109	80.4
General averages,		15	20			3067	89	

* To anchor outside.

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From New York to Bristol, or Liverpool, viz., from the Wharf to Kingroad, or the Docks.

Sailed.	Arrived.	Time.		Yearly av time of trip.		Dist. run in nautic'l miles.	Passeng's	Yearly av of pass'rs per trip.
		d.	h.	d.	h.			
May 7, 1838,	May 22, 1838,	14	0			3218	66	
June 25,	July 8,	12	14			3099	91	
August 16,	August 30,	13	2			3058	87	
October 4,	October 16,	12	12			3068	127	
November 23,	December 7,	13	16	13	4	3152	80	90.1
February 25, 1839,	March 12, 1839,	14	12			3133	36	
April 22,	May 7,	15	0			3332	113	
June 13,	June 26,	13	6			3033	115	
August 1,	August 13, 4 30 P.M.	12	10½			3067	64	
September 21,	October 4,	13	0			3034	43	
November 16,	November 30,	13	10	13	17	3038	31	67
March 19, 1840,	April 2, 1840,	14	4			3101	52	
May 9,	May 23,	14	2			3076	137	
July 1,	July 14,	13	12			3138	152	
August 18,	August 31,	13	1			3030	69	
October 10,	October 23,	13	6			3028	97	
December 9,	December 23,	14	9	13	21	3071	70	96.1
May 1, 1841,	May 14, 1841, 7 30 P.M.	13	1			3208	94	
June 19,	July 3,	14	2			3109	81	
August 7,	August 20,	12	10			3081	68	
September 25,	October 8,	12	13			3063	43	
November 23,	December 6,	13	5	13	1½	3049	30	62.4
April 28, 1842,	May 11, 1842, 4 A.M.	12	7½*			3248	77	
June 16, 2 30 P.M.	June 29, 7 30 A.M.	12	12			3225	99	
August 11, 2 15 P.M.	August 24, 2 P.M.	12	19			3106	70	
September 29, 2 P.M.	October 12, 11 P.M.	13	4			3048	85	
November 17,	November 30, 10 A.M.	12	15	12	16	3077	29	62
General averages,		13	9			3107	76	

* To light vessel.

Description of a Reflecting Lantern and a Heliotrope, used by Major J. D. Graham, *as meridian marks for great distances, in* 1841, *while tracing, in his capacity of U. S. Commissioner, the due north line from the monument at the source of the river St. Croix.*

The lantern was constructed by Messrs. Henry N. Hooper & Co., of Boston, under Major G.'s directions. It was similar in form to the Parabolic Reflector Lantern, sometimes used in lighthouses, but much smaller, so as to be portable.

The burner was of the argand character, with a cylindrical wick, whose transverse section was half an inch in diameter, supplied with oil in the ordinary manner. This was placed in the focus of a parabolic reflector, or paraboloid, of sheet copper, lined inside with silver about one-twentieth of an inch in thickness, polished very smooth and bright. The dimensions were as follows:—

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	Inches.
Diameter of the base of frustrum of reflector, - -	16.
Distance of vertex from base, - - - -	3.75
Distance of focus from vertex, - - - -	2.25
Diameter of cylindrical burner, - - - -	.50
Diameter of a larger burner, which was never used, but which, by an adapting piece, could be easily substituted, -	1.25

The instrument answered the purpose for which it was intended, admirably well, and was of great use in tracing the due north line. While it occupied the station at Park's Hill, 15 feet above the surface of the ground, or 828 feet above the sea, in the latter part of September, and early part of October, 1841, the light from it was distinctly seen with the naked eye, at night, when the weather was clear, from Blue Hill, whose summit, where crossed by the meridian line, is 1071 feet above the sea; the intervening country averaging about 500 feet above the sea, and the stations being 36 miles apart.

The light appeared to the naked eye, at that distance, as bright, and of about the same magnitude, as the planet Venus. Viewed through the transit telescope, of 43 inches focal length, it presented a luminous disk, of about thirty seconds of arc in diameter. From its brilliancy at that distance, Major G. has no doubt that it would have been visible to the naked eye at 50 miles, and through the telescope at 100 miles, could stations, free from interposing objects, have been found so far apart.

It was remarked, that the wick employed by Major G. was considerably smaller than that usually made, even for parlor lamps; and to this cause he attributed, in a great measure, the perfection with which the parallel rays were transmitted from the reflecting parabolic surface, so as to make them visible at so great a distance. Though a greater quantity of light is generated by a larger wick, the portion of rays reflected in a direction parallel to the axis, and which alone come to the eye, is the smaller as the flame transcends the focal limit. The size of wick most advantageous for use, may easily be determined by experiment: Major G.'s impression is, that, the smaller its transverse section, provided it is only large enough to escape being choked up by the charred particles, even one-third, or perhaps one-fourth, of an inch, the farther the light would be visible.

It has occurred to Major G. that lanterns of this description might be used with great advantage as station marks, in extensive trigonometrical surveys, requiring primary triangles of great length of sides. A revolving motion might be given to the lanterns, so as to make the light transmitted from them visible from many different stations within short intervals of time. Their simplicity, and the ease with which they are managed, would perhaps give them, for such purposes, a great advantage over the Drummond, or Bude, lights, even though they be not so brilliant as the latter.

The heliotrope, which he employed in the day time, was made by order of Mr. Hassler, at the instrument shop of the coast survey office. It was a rectangular parallelogram of good German plate glass, $1\frac{4}{5}$ by $1\frac{1}{5}$ inch in size, giving an area of reflecting surface of $2\frac{16}{100}$ square in. This also was seen at the distance of 36 miles. *Proc. Am. Philos. Soc.*

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Practical & Theoretical Mechanics & Chemistry.

Notice of the Discovery of a new Metal by Mosander.

Extracted from Wöhler and Liebig's Annal. der Chim. und Pharm.

At the meeting of the Scandinavian Naturalists, at Stockholm, Mosander made a communication upon the subject of cerium and lanthanum. He exhibited, in the first place, some pale, clear, lemon-yellow oxide of cerium—described, generally, the characters of the protoxide and peroxide of cerium, and showed some of their salts. He then showed the colorless oxide of lanthanum, which remains colorless after ignition, and whose salts are also colorless. He then stated that the ores of yttrium, cerium and lanthanum, are accompanied, in the mineral kingdom, by a twin-brother, which is the cause of the known rose-red color of their salts, and which it is very difficult to separate from them, in consequence of their having the same solvents and precipitants. This body is the oxide of a hitherto unknown metal, to which Mosander has given the name didymium, (from the Greek διδυμος, a twin.)

The oxide of this metal is the cause of the brown color of the oxide of cerium, and of the brick-red of the oxide of lanthanum.

He also showed the dark brown oxide of didymium, and, for the sake of comparison, some crystalized salts of cerium, lanthanum, and didymium. The last are red.

He went on to say that he had not as yet succeeded in discovering a method for the perfect separation of these metals, and that this was the cause of the long delay of his communication on the subject of lanthanum; and that, had it not been for peculiar circumstances, he would not even yet have presented the results of his labors, which he could not consider but as imperfect. The preparations, he remarked, were not yet absolutely pure, but they were as nearly so as they could be made by spontaneous crystalizations of large masses of the solutions, in which the oxides had previously been purified as far as possible. A determination of the atomic weight of this metal, on account of the impurity of the preparations, he considered at present useless.

Notice of Walker's Hydraulic Elevator. By T. Ewbank.

To the Committee on Publications:

Gentlemen—I beg permission to reply to a remark of Mr. Wright, who, in the March number of the London Mechanics' Magazine, after paying a high, and, I fear, undeserved, compliment to my work on hydraulics, has inadvertently ascribed to it a defect which really does not belong to it, though doubtless it has many others. He observes—"There appears to be nothing on the subject of hydraulics that has escaped his researches, if we except a late invention of our countryman, Mr. John Walker, of Crooked Lane, London; the knowledge of which could not have crossed the Atlantic when Mr. Ewbank's book was published, or he would not have neglected to mention so novel and so simple an apparatus for raising water."

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Mr. Walker's machine (described in the Journal of the Franklin Institute for August, 1842,) is the *Canne hydraulique* of French writers; three modifications of which Mr. Wright will find at pp. 372–3 of my book. Details of mechanism for *moving* hydraulic apparatus did not enter into my plan, and would have been incompatible with it; but had not the pages referred to passed the press ere Mr. Walker's "Elevator" was announced, his mode of combining two, or more, and of communicating motion to them, would have been noticed.

To the editor of the London Mechanics' Magazine, I feel peculiarly grateful for the flattering notice he has taken of my humble volume, in his popular and widely extended journal; and have no doubt that he will correct the unintentional error of his correspondent.

New York, April 27, 1843. THOS. EWBANK.

Cement Marble.

Translated for the Journal of the Franklin Institute, from the Journal des Chemins de Fer. By JOHN C. TRAUTWINE, Civ. Eng. and Architect.

An interesting paper on the cement marble of Mr. Keene, was recently read before the London Society of Arts.

This marble is a combination of sulphate of lime (gypsum) with alum. The gypsum undergoes the same preparation as the ordinary plaster of Paris, being deprived of its water of crystalization by heating it in a furnace. It is afterwards tempered with a saturated solution of alum, and, when this composition is again calcined and reduced to powder, it is ready for use. The cement is used like stucco; but, as it is susceptible of a high degree of polish, and may be colored by simply dissolving the proper mineral colors in the same water with which the powdered cement is mixed for the workman, we may thus obtain fine imitations of mosaics, and of veined marbles. This cement is not applicable to situations exposed to the influence of the weather, or of water; but it has been used in stucco for the interior of Windsor, Buckingham, and other, palaces. As it is of great hardness, it is well adapted to use as a facing instead of tiles; and it makes a good marquetry for paving. The interior of a church in London, and many other public buildings, have been paved in this manner.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Digest of the Results of Experiments on Friction, performed by Capt. Morin, of the French Corps of Artillery. By Prof. J. F. FRAZER.

It has been thought advisable to digest into a tabular form, and publish in our journal, the results of a series of very elaborate and careful experiments, upon the subject of friction, performed at Metz, in the successive years from 1831 to 1834, under the sanction of the French government, by Capt. Arthur Morin, of the French corps of artillery.

These results have been more than once republished, and have been incorporated into several works upon practical mechanics; but we believe that no full statement of them has ever been made accessible to the American mechanic, and we have, therefore, carefully

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ferring no small favor upon the cause of our domestic arts.

In order to the more full appreciation of these results, it may not be useless to preface these tables by a very short sketch of the history of the study of this important mechanical agent.

The French philosopher, Amontons, appears to have been the first who undertook a regular series of experiments for the purpose of determining the value of friction; his results were first published in 1699. He arrived at the conclusion that friction was not affected by any increase or diminution of surface, but varied with the pressure imposed. He does not seem to have attempted any accurate valuation of this ratio for different substances, but states generally that the friction of one surface, sliding over another, is about one-third of the pressure, when the surfaces were clean, and that, when lubrics were used, it was the same for woods as for metals. He also concluded that it increased or diminished with the velocity, and varied in the compound ratio of the weight and pressure upon the rubbing parts, the length of time of their contact, and the velocity of their motion.

These views were adopted and advocated by De la Hire, and first questioned by Lambert. Parent proposed to reinvestigate the subject by means of the inclined plane, which plan was adopted and developed by the celebrated mathematician Euler. He supposed friction to be caused by the greater, or less, asperities of the two surfaces brought into actual contact, and, therefore, necessarily dependent upon the pressure; and assigned, as its practical value, one-third of the pressure, which was the conclusion of Amontons, but he doubted the effect of velocity upon it. We owe to him the beautiful demonstration of the fact, that, when a body rests upon an inclined plane, the angle of inclination of which is increased until the body begins to slide down, the ratio of the friction to the pressure is measured by the tangent of the angle of inclination; which fact furnishes a simple and easy method of determining this ratio.

Muschenbrock contended that friction increased with the surfaces. Bossut distinguished rolling from sliding friction, but erred in considering it as affected by time, but not proportional to the pressure, or mass. Desaguliers studied the subject attentively, and cites the experiments of Camus, which, however, were tried upon too small a scale to be satisfactory.

In 1779, seeing the vast importance of the full experimental development of the laws of this resistance, the celebrated philosopher Coulomb, at the request of the Academie des Sciences of Paris, undertook, at the arsenal at Rochfort, a very extensive series of experiments, which are, in fact, the first of any importance upon this subject, and of which the results are still very generally adopted by philosophers and mechanics.

He was led to the conclusion that, as a general law, other things being the same, the friction of the same surface, sliding over another, is proportional to the pressure with which the surfaces are urged together; but he thought that, in extreme cases, he found a deviation from this law; for that, when the pressures were extremely intense,

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The deviation was, however, so inconsiderable, and happened only in such extreme cases, that it might, for the most part, be neglected.

The importance of this deduction is shown by the conclusion drawn from it, that, in the case of any body sliding upon another, the friction will be the same, whether the body move upon its face, or upon its edge. Thus, if we suppose a body to weigh 16 oz., and to present upon its face a surface of 16 square inches, while its edge has a surface of but one square inch, the friction of this body, while moving upon another, will still be the same, whether it be moving upon its face, or upon its edge. This law has, however, at all events, an evident limit, when its edge becomes sufficiently sharp to cut into the surface upon which it moves.

Another law which Coulomb deduced, and which has been confirmed by all subsequent experimenters, is, that friction is an uniformly retarding force, and is, consequently, independent of the velocity. The only exception to this, found by Mr. Rennie, is in the case of fibrous substances, such as cloths, very soft woods, &c.

Coulomb also came to the conclusions—

1. That friction varies with the quality of the surfaces, amounting sometimes, in the case of newly-planed woods, to half the pressure; while with hard woods, upon metals, it is only about one-fifth of the same.

2. That, as the surfaces are worn by attrition, the friction is generally diminished; but this has a limit, and the friction soon reaches a minimum. In woods, it was reduced by attrition from one-half to one-third of the pressure.

We shall see, directly, that M. Morin remarks upon this deduction, as pointing out the circumstances which led Coulomb into error in endeavoring to determine the friction between different substances.

3. That, between woods, the friction is less, when the grains cross each other, than when they are in the same direction, being in the former case one-fourth, in the latter one-half, of the pressure.

4. In general, friction is greater between surfaces of the same kind, than between those of different kinds.

This deduction, which has been so generally adopted since Coulomb's time, seems to be completely refuted by the experiments of Morin.

5. That friction diminishes as the smoothness of the surface is increased.

The experiments of Ximenes accord very closely with those of Coulomb.

Prof. Vince, (see Phil. Trans., 1785,) dissatisfied with the method in which these, and other experiments upon the same subject, were tried, resolved upon attempting to determine, by means of a different principle, whether the friction was solely dependent upon pressure. His method was highly ingenious, and apparently accurate, and his conclusion was, that the friction was not proportional to the pressure alone, but was also dependent upon the extent of surfaces in contact; so that a body, such as we have supposed above, would have less

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friction when moving upon its edge, than when in motion upon its face. The experiments, however, were upon too small a scale to gain an implicit reliance.

The experiments of Mr. Rennie (Phil. Trans., 1829,) led him to results which, for the most part, confirm those of Coulomb. He found—

1. That the laws which govern the retardation of bodies gliding over each other, vary with the nature of the bodies.

2. That, with fibrous substances, (such as cloth, &c.,) friction is increased by surface and time, and diminished by pressure and velocity.

3. That, with harder substances, such as woods, metals, and stones, and within the limits of abrasion, the amount of friction is as the pressure, without regard to surface, time, or velocity.

4. That, with dissimilar substances sliding over each other, the measure of friction will be determined by the limit of abrasion of the softer substance.

5. That friction is greatest with soft, and least with hard, substances.

6. That the diminution of friction by unguents (lubrics) depends upon the nature of the unguent, without reference to that of the moving surfaces.

7. That the very soft woods, stones, and metals, approximate to the laws which govern fibrous substances.

The very great discrepancies thus shown to exist between the results obtained by the best experimenters, as well as the fact that the most extensive and valuable set of experiments (those of Coulomb) were tried chiefly upon materials used in naval constructions, induced Capt. Arthur Morin, in the year 1831, to undertake a series of investigations, which, it is not too high praise to say, for elegance of conception, accuracy of demonstration, and careful avoidance of all con ceivable error, have not been paralleled in the history of this subject. These experiments were tried at Metz, and under the especial patronage of the French government, by whom he was provided with every facility for his undertaking.

The arrangements of M. Morin for accomplishing his object, we do not propose to describe in detail here, as they would require, for their comprehension, numerous and elaborate drawings; they may be seen, by those who desire it, by reference to his memoirs upon the subject, a copy of which is in the library of the Institute. The method which he adopted enabled him to conduct his experiments with much greater variations, both of surface and pressure, than had been formerly used; while, at the same time, the results were recorded by the apparatus itself with mathematical accuracy; and these records were preserved for future inspection and reference.

Under these circumstances, these investigations assume a peculiar value, and seem to justify our reliance upon their perfect accuracy. They will, therefore, we conceive, as they become fully known, entirely supersede all former experiments upon the same subject, and form, as Coulomb's and Rennie's have done, up to this time, the basis of all our calculations of this important resistance.

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pressure, (from 200 to 6000 lbs.) the friction remained proportional to the pressure; so that the ratio, obtained by dividing the number expressive of the actual friction, by the pressure, remained always constant for the same substance.

We may observe that these experiments did not extend to those soft and fibrous tissues, such as cloth, &c., which were found by Vince and Rennie to obey another law.

2. That the friction is entirely independent of the velocity.

3. That it is entirely independent of the extent of surface.

These laws were found to hold good, even at pressures so great that the surfaces were materially abraded. M. Morin also satisfied himself that they governed the case of the friction of bodies during concussion.

Upon an examination of these tables, it will be found that the numbers expressive of the ratio of friction to pressure, determined by M. Morin, do not agree with those found by Coulomb, being in general considerably greater. In explanation of this difference, M. Morin adverts to the observation of Coulomb, that the surfaces used by him became more smooth and polished under attrition; which was never found by M. Morin to be the fact, when the surfaces, at the commencement of the experiment, were perfectly clean, and free from unguents. When, however, in the course of his experiments, a surface was accidentally used which had become unctuous in a former experiment, this phenomenon of the increasing polish was observed, and the ratio of the friction to the pressure was found to coincide very nearly with the number obtained by Coulomb. From this fact, M. Morin is led to the belief that the surfaces used by Coulomb were not prepared with sufficient care, but that they were, for the most part, more or less unctuous.

The observation made by M. Morin, that whenever two perfectly clean surfaces were moved in contact with each other, both were worn into alternate ridges and channels, accompanied by the formation of a powder, is not without great interest in the study of our subject.

This effect was produced invariably, whenever the pressures were tolerably great, and was frequently attended, in the experiments upon the woods, by the odor of burning wood.

The effect was found to be very great in the case of fibrous metals (such as wrought iron) sliding over each other; less in the case of granular metals (such as cast iron) sliding upon the fibrous; and least of all, when the granular metals were slid over each other.

M. Morin's experiments agree perfectly with those of Mr. Rennie in showing that, when lubrics are used, the ratio of the friction to the pressure is independent of the nature of the sliding surfaces. That, for instance, when lard is interposed between two surfaces of metal, the friction is that of lard upon lard, and not that of metal upon metal.

When the surfaces are wiped dry after the application of the lu-

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diate between the two cases.

The conclusion come to by Coulomb, which has so completely passed into a general law of friction, that the friction between similar, is greater than that between dissimilar, substances, is not at all sanctioned by the experiments before us.

In reference to the influence of the duration of contact between the substances upon the friction, (by Coulomb called the friction of rest,) M. Morin shows very clearly its variation according to the nature of the substance experimented upon. When hard bodies rest upon each other, it reaches its maximum very quickly—with soft bodies, very slowly. When wood rested upon wood, the limit was attained in a few minutes—when the metals were in contact with wood, it required several days before the greatest effect was attained.

With these remarks, we submit the tabulated results of these experiments to our readers. It will be recollected that these tables present, as it were, a digest of the labors of M. Morin; every result thus recorded being a mean of a number, frequently of a very great number, of experiments, tried under every conceivable variety of circumstances, with large and small surfaces, under light and heavy pressures, with low and high velocities; the machine being so regulated as to cause, at one time, an accelerated—at another, a retarded—at another, an uniform—velocity. Of all these circumstances, the pressure alone was found to affect the friction; and the ratio of these (the substance remaining the same) varied within limits far less than those which may fairly be allowed in such experiments.

Table I, presents the results of the friction of substances sliding upon each other. In the first column is recorded the nature of the surface which was movable in the experiment, together with that of the surface at rest over which it slid. In the second column is indicated the direction of the fibres of the substances in relation to the direction of the motion, and to each other. The remainder contains the various numbers expressive of the constant ratio of the friction to the pressure. These are expressed by the decimal obtained by dividing the measure of the actual friction by the pressure which caused it. This portion of the table is divided into two compartments, one containing the results obtained during the motion; the other, those given when, after remaining in contact for a considerable length of time, the bodies were first caused to move over each other. Each of these compartments is again subdivided into columns, containing the results with different lubrics; the first recording those obtained when the surfaces were perfectly clean; the last (headed surface unctuous) recording those given when the lubric had been carefully wiped off, so as to leave the surface barely unctuous to the touch. With this explanation, we believe the table will be perfectly intelligible.

Table II is drawn up in the same general form, and contains the results of the experiments upon the friction of axles of different materials upon their bearings, and, among other important information, conclusively shows the advantages to be derived from attention to the method in which the lubric is supplied in such cases.

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TABLE I—*Table showing the Result of Morin's Experiments on the Friction of Plane Surfaces, sliding over eac*

Materials.		Direction of the Fibres.	Ratio of the Friction to the Pressure. During Motion.—Lubric. None.	Water.	Dry soap.	Tallow	Lard.	Sweet oil.	Lard & pl'bago	As-phalte.	Cart grease.	Surface unctu's	After Contact.—Lub None.	Water.	Dry soap.	Tallow	Lard.
Oak,	Sliding upon Oak.	Fibres parallel to the direction of the motion.	.478	.25	.164	.075	.067					.108	.625	.71	.44	.164	
"		Fibres of sliding pieces perpendicular to those of the sleepers, and to the motion.	.314										.54				
"		Fibres of both pieces at right angles to the direction of the motion.	.336			.083	.072					.145				.254	
"		Fibres of sliding pieces vertical—of sleepers parallel to the motion.	.192										.271				
Elm,		Fibres parallel to the direction of the motion.	.432		.137	.070	.060					.119	.694		.411	.142	.277
"		Fibres of elm at right angles to those of the oak and to the motion.	.45										.57				
Ash,		Fibres parallel to the direction of the motion.	.40										.57				
Fir,		do.	.355										.52				
Beech,		do.	.36			.055						.153	.53				.330
Wild Pear,		do.	.37										.44				
Service tree,		do.	.40										.57				
Wrought iron,		do.	.619	.256	.214	.085							.62	.649		.108	
Cast iron,		do.	.49	.218	.189	.078	.075	.075				.104		.646		.101	.103
Brass,		do.	.617			.069						.100	.62			.095	
Tanned leather		Fibres of oak parallel. Leather laid flat.	.296														
Curried "		" "	.265										.74				
Sole "		" "	.52										.605				
" "		" Leather on edge.	.335										.43	.79			
Hemp—bands,		Fibres parallel.	.52	.29									.64				
" plait of small cords		"	.32										.50				
Hemp in shreds		Threads perpendicular to the motion.		.332										.869			
" old rope 1½in. diam		"	.52										.79				

Elm,	upon elm.	Fibres parallel.		.139								.140			.217		
Oak,		"	.246		.136	.073	.066					.136	.376			.178	
Cast iron,		"	.195			.077		.061	.091			.125					
Wrought iron,		"	.252			.078	.076	.055				.138					
Oak,	upon cast iron.	"	.372			.08						.168					
Elm,		"				.066					.098	.135					
Hornbeam,		"	.394			.07	.071	.068	.058	.06	.095	.136				.131	.136
Lignum vitæ,		"				.076		.076				.121					
Wild Pear,		"	.436			.067	.068					.173					
Tanned leather		Leather flat.	.559	.365		.159		.133				.229		.621			
" "		" on edge.		.338				.135			.267			.615			
Cast iron,			.152	.314	.197	.100	.070	.064	.055			.144	.162			.100	
Wrought iron,			.194			.103	.076	.066			.124		.194			.101	
Steel,			.202			.105	.081	.070				.109				.108	
Brass,			.189			.072	.068	.066			.134	.115					
Bronze,			.217			.086		.077				.098				.106	
Hemp in shreds		Shreds perpendicular to the motion.						.153									
Oak,	upon wr't iron.	Fibres parallel.				.194						.149					
Lignum vitæ,						.098		.072				.166					
Cast iron,						.098	.058	.063			.155	.143				.100	
Wrought iron,			.138			.082	.081	.070				.177	.137			.115	
Steel,						.093	.076										
Bronze,			.161			.081		[077	.089			.166					
Lignum vitæ,	upon bronze.					.082		.053				.146					
Leather,		Leather laid flat.				.241		.191	Bronze wet with water			.287					
"		" on edge.				.138		.135				.244					
Cast iron,			.147			.085	.070	.067				.132					
Wrought iron,			.172			.108	.075	.078			.168	.160					
Steel,			.152			.056		.053	.067		.170						
Bronze,			.201					.058				.134					

TABLE I.—*Table showing the Result of Morin's Experiments on the Friction of Plane Surfaces, sliding over each*

Materials.		Direction of the Fibres.	Ratio of the Friction to the Pressure. During Motion.—Lubric. None.	Water.	Dry soap.	Tallow	Lard.	Sweet oil.	Lard & pl'bago	As-phalte.	Cart grease.	Surface unctu's	After Contact.—Lub None.	Water.	Dry soap.	Tallow	Lard.
Oak,	Sliding upon Oak.	Fibres parallel to the direction of the motion.	.478	.25	.164	.075	.067					.108	.625	.71	.44	.164	
"		Fibres of sliding pieces perpendicular to those of the sleepers, and to the motion.	.314										.54				
"		Fibres of both pieces at right angles to the direction of the motion.	.336			.083	.072					.145				.254	
"		Fibres of sliding pieces vertical—of sleepers parallel to the motion.	.192										.271				
Elm,		Fibres parallel to the direction of the motion.	.432		.137	.070	.060					.119	.694		.411	.142	.277
"		Fibres of elm at right angles to those of the oak and to the motion.	.45										.57				
Ash,		Fibres parallel to the direction of the motion.	.40										.57				
Fir,		do.	.355										.52				
Beech,		do.	.36			.055						.153	.53				.330
Wild Pear,		do.	.37										.44				
Service tree,		do.	.40										.57				
Wrought iron,		do.	.619	.256	.214	.085							.62	.619		.108	
Cast iron,		do.	.49	.218	.189	.078	.075	.075				.104		.646		.101	.103
Brass,		do.	.617			.069						.100	.62			.095	
Tanned leather		Fibres of oak parallel. Leather laid flat.	.296														
Curried "		" "	.265										.74				
Sole "		" "	.52										.605				
" "		" Leather on edge.	.335										.43	.79			
Hemp—bands,		Fibres parallel.	.52	.29									.64				
" plait of small cords		"	.32										.50				
Hemp in shreds		Threads perpendicular to the motion.		.332										.869			
" old rope 1½in. diam		"	.52										.79				

Elm,	upon elm.	Fibres parallel.		.139								.140			.217		
Oak,		"	.246		.136	.073	.066					.136	.376			.178	
Cast iron,		"	.195			.077		.061	.091			.125					
Wrought iron,		"	.252			.078	.076	.055				.138					
Oak,	upon cast iron.	"	.372			.08						.168					
Elm,		"				.066					.098	.135					
Hornbeam,		"	.394			.07	.071	.068	.058	.06	.095	.136				.131	.136
Lignum vitæ,		"				.076		.076				.121					
Wild Pear,		"	.436			.067	.068					.173					
Tanned leather		Leather flat.	.559	.365		.159		.183				.229		.621			
" "		" on edge.		.338				.135			.267			.615			
Cast iron,			.152	.314	.197	.100	.070	.064	.055			.144	.162			.100	
Wrought iron,			.194			.103	.076	.066			.124		.194			.101	
Steel,			.202			.105	.081	.070				.109				.108	
Brass,			.189			.072	.068	.066			.134	.115					
Bronze,			.217			.086		.077				.098				.106	
Hemp in shreds		Shreds perpendicular to the motion.						.153									
Oak,	upon wr't iron.	Fibres parallel.				.194						.149					
Lignum vitæ,						.098		.072				.166					
Cast iron,						.098	.058	.063			.155	.143				.100	
Wrought iron,			.138			.082	.081	.070				.177	.137			.115	
Steel,						.093	.076										
Bronze,			.161			.081		[077	.089			.166					
Lignum vitæ,	upon bronze.					.082		.053				.146					
Leather,		Leather laid flat.				.241		.191	Bronze wet			.287					
"		" on edge.				.138		.135	with water			.244					
Cast iron,			.147			.085	.070	.067				.132					
Wrought iron,			.172			.108	.075	.078			.168	.160					
Steel,			.152			.056		.053	.067		.170						
Bronze,			.201					.058				.134					

TABLE II.—*Experiments upon the Friction of Axles upon their Bearings.*

		Ratio of Fric. to Pressure			
		Oil	Lard	Tallow.	Unct'ns
Wrought or cast iron upon Cast iron or bronze	Lubric renewing itself	.075	.075	.075	.13 to .16
Wrought or cast iron upon Cast iron or bronze	" constantly renewed	.054	.054	.054	
Bronze on bronze	" renewing itself	.101		.093	
Bronze on cast iron	" constantly renewed	.052		.045	
Lignum vitæ on cast iron	" renewing itself		.116		.153
Lignum vitæ on Lignum vitæ	" constantly renewed		.070		
Cast iron on Lignum vitæ	" "	.092		.092	.100
Wrought iron on Lignum vitæ	" renewing itself	.114	.135		.118

A new Method of distinguishing between the Spots of Arsenic and Antimony obtained in the Apparatus of Marsh. *By* FRESENIUS.

Extracted from Wöhler and Liebig's Annal. der Chemie for September, 1842.

The description of the apparatus devised by Mr. Marsh for the detection of arsenic, in the case of suspected poisoning by a preparation of that metal, and the method of its use, will be found in full in a former number of our journal, (Jour. Fr. Inst. vol. xviii, p. 338, 2d ser.) The great liability to error with this apparatus, lies in the difficulty of distinguishing between the traces left by the two metals, arsenic and antimony, and the consequent doubt thrown on the results obtained. The following method, extracted from the Annalen der Chemie und Pharmacie, for September, 1842, seems to us the most simple and unexceptionable for the supplying of this want, and the perfection of the apparatus, as an agent in medico-legal inquiries.

Obtain marks, as distinct as possible, in the usual way with the apparatus, and proceed (changing occasionally the tubes) as long as spots are given.

Then remove the vessel in which the gas is generated, and substitute an apparatus for the generation of sulphuretted hydrogen, (being careful, of course, that the materials used are free from arsenic.) Pass the stream of this gas over the metallic spots, so slowly that the gas will just burn as it issues from the end of the tube, which is drawn out to a fine orifice.

While the gas is coming over, heat the tube by means of a spirit-lamp, beginning at the outer end of the apparatus, and passing the lamp slowly along in a direction contrary to the direction of the current of gas. By this means the metal, or metals, present are converted into sulphurets. When this conversion is perfect, remove the apparatus for the generation of sulphuretted hydrogen, and replace it by an apparatus for the generation of hydrochloric acid gas, interposing a larger tube, filled with cotton, between this apparatus and the tube in which the spots are contained. Let the stream of this gas pass

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few seconds if they be thicker; for this substance is very volatile in an atmosphere of hydrochloric acid.

On the other hand, the sulphuret of arsenic, if any be present, will be unaffected, and, after all the antimony is removed, may be obtained by sealing the end of the tube, and filling it with aqua ammoniæ, by which it will be dissolved, and may be again deposited, by evaporation, in a watch-glass, or other convenient vessel, and may be subjected to any tests which the operator may think proper.

British and American Royal Mail Co.'s Steam Ship Hibernia.

We have great pleasure in noticing this magnificent steamer. On going on board of her at the Broomielaw, we were first shown into the main saloon, and were as much delighted by its elegant appearance, as we were struck by its great size. It is constructed on a plan introduced by Mr. Napier into the first Halifax steamers, being built upon the main deck, and extending from the mainmast to the taffrail, ample room being allowed on each side of it for conveniently working the vessel; the stanchions, or frames for its support, pass through the main deck to the second deck, and, being firmly fixed to both, render it perfectly secure.

On descending the first flight of stairs into the engine-room, a gallery, chiefly of malleable iron, which passes entirely round the engines, gives an excellent view of the whole machinery. The next flight leads to the starting stage, which is of open cast-iron work, and fills up the space between the engines. The last flight leads to the lower floor and boilers. The cylinders are 77½ inches diameter, and 7 feet 6 inches stroke. The starting gear is very beautiful and effective; a large malleable iron wheel, highly polished, with appropriate handles, is keyed into a shaft, having on it a pinion which takes into a sector on the valve-shaft, enabling three men to work the large D valves easily. The handle for disengaging the eccentric rod throws the pinion into gear with the sector, as soon as the eccentric rod has cleared the pin, so that the starting wheel can never be driven round by the motion of the valve-shaft. The throttle-valve, injection-cock, and blow-through-valve-handles, are all within reach of the engineer at the starting-wheel, as is also the handle for throwing the expansion valve in or out of gear.

The counter, for registering the number of strokes, is worked by the air-pump-crosshead of the starboard engine, being placed in the arch of the framing above the air-pump. Opposite to it, on the corresponding arch of the larboard engine, is placed the clock. From this counter may be told at a glance the number of strokes that the engines have made, from the time of the vessel's leaving England, until her return from America. The side-levers are much shorter, in proportion to the length of the stroke, than is generally the case, and on this account the engines take up much less room. The levers are made, in this instance, of just sufficient length to allow of the air-

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at all crowded, and giving the engineers plenty of space for the performance of the necessary operations about them. The great length of the side-rods fully justifies this shortness of lever, they being more than 1½ times the length of stroke, and the half-versed sine of the arc described by the lever being only about four inches, causes the side-rods to work very slightly off the perpendicular, which would be but very little diminished by increasing the length of the lever to the standard of general practice. Considering the great weight of the side-levers, and the immense power by which they are urged, it might be expected that the main centre brasses would speedily wear out; on the contrary, however, the experience derived from other engines of Mr. Napier's construction, warrants us in considering them almost indestructible; for, after many years' use in those of them which we have examined, the wear is almost imperceptible, proving incontrovertibly that the friction on the main centre is scarcely anything.

The valve-casings are fitted with expansion joints, having brass stuffing-box covers. The air-pumps are of brass, as are also the buckets; the rods are cased with brass, which passes a considerable distance into the eye of the bucket; the end of the rod being also sheathed, effectually preventing any galvanic action taking place. There are two discharge-valves, one on the top of the barrel of the pump, and the other in the hot-well, and also a stop-valve in the discharge-pipe. The four bilge-pumps are placed under the midship-levers, all of which, as well as the plungers, are of brass; the suction and discharge-pipes are all of copper. The blow-through-escape-valve has its pipe passing under the air-pump into the condenser, which is an improvement upon the usual plan of attaching it to the bottom of the air-pump, as, in case of anything getting into it and preventing its shutting, the air-pump is not thereby prevented from doing its work. The other plan has been the cause of many breakages. The feed-pumps are placed according to Mr. Napier's usual plan, above the wing-side levers, or the hot-well, from which they are supplied, and into which the superfluous feed-water is returned.

There are four distinct boilers, having four fires in each. The flues do not pass over the top of the fires, but have two tiers at the back end. Two of the boilers are fired from the fore, and two from the after, part of the vessel. All four are connected by stop-valves to a general receiver, or steam-chest, from which the steam passes by two distinct malleable iron pipes under the first platform to the valve-casings. The boilers and steam-pipes are felted, and the cylinders are felted and cased with wood, which causes the engine-room to be as comfortable as any part of the vessel. Each of the boilers is fitted with an apparatus by which the brine is pumped out. This, in its passage, is made to give out part of its heat to the feed-water. At the after-end of the boilers is a malleable-iron stair, for the greater convenience of the firemen, to the coal-boxes and deck. The fore and after holds and coal-boxes above the boilers, and alongside the engines, will contain coals for 24 or 30 days' consumption.

The principal dimensions are as follows—Length of keel and fore-

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rake, 218 feet; depth of hold, 24 feet; breadth of beam, 36 feet; diameter of paddles, 30 feet 4 inches. Glas. Prac. Mech. & Eng. Mag.*

Notice of an Altitude and Azimuth Instrument, presented to the Royal Astronomical Society by Admiral Greig. Made by M. Reichenbach, of Munich.

The diameter of the azimuth circle is 15, and of the altitude circle 12, inches. The divisions, which are of silver, read to 4″ of space by 4 verniers upon each circle. The instrument is one of the kind which admits of repetition both in the horizontal and vertical planes, and is furnished with two telescopes; the principal one resting in Ys attached to the azimuth index, and the other placed below the azimuth circle, according to the ordinary arrangement. But a peculiarity deserving especial notice, is the manner in which the usual difficulty of observing near the zenith is obviated. A diagonal reflector, in this case a prism, directs the rays through one of the pivots of the transit axis, in which the diaphragm and eye-piece are consequently placed, and thus the observer remains in an easy, unaltered position, whatever may be the altitude of the object observed. It is almost superfluous to add, that the graduation axes, tangent screws, and other delicate parts of this instrument, exhibit all the proofs of care and skill for which the maker was so long celebrated. Lond. & Edinb. Philos. Mag.

Method of distinguishing Zinc from Manganese, in Solutions containing Ammoniacal Salts. By M. Otto.

If solutions of chloride of zinc and chloride of manganese, containing much hydrochlorate of ammonia, be rendered alkaline by solution of ammonia, the addition of the smallest quantity of solution of hydrosulphuric acid precipitates white hydrated sulphuret of zinc, whilst no effect is produced by it in the solution of manganese, more being required to obtain a precipitate of the sulphuret of the latter metal. If acetic acid be then added to the solutions, the sulphuret of manganese dissolves very readily, whilst that of zinc remains undissolved. M. Otto advises the use of hydrosulphuric acid, and not hydrosulphate of ammonia, because the latter, always containing persulphuret, may occasion mistakes, since acetic acid separates sulphur from it. If, for example, it be required to determine whether iron filings contain brass, they are to be dissolved in aqua regia, the peroxide of iron is to be precipitated by ammonia, the liquor is then to be acidulated, the copper precipitated by hydrosulphuric acid, and ammonia is then to be added to the filtered liquor, which usually still contains a sufficient quantity of hydrosulphuric acid. If a white precipitate be formed, which does not dissolve in acetic acid, it shows that zinc is present. M. Wackenroder has especially recommended the solubility of sulphuret of manganese in acetic acid, to separate manganese from other metals.—*Jour. de Pharm. et de Chem.*, Sept. 1842. Ibid.

* From this excellent work we extracted the article on the crank, in our last number, but accidentally omitted the proper credit.

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Moon	Days	Thermometer Sun Rise.	Thermometer 2 P.M.	Barometer Sun Rise.	Barometer 2 P.M.	Wind Direction.	Wind Force.	Water Fallen in rain	State of the Weather, and Remarks.	
⊗	1	28°	30°	29.75	29.75	W.	Moderate		Cloudy.	Cloudy.
	2	16	22	29.83	30.00	W.	Brisk		Clear.	Clear.
	3	14	21	30.10	30.10	NW.	Moderate		Clear.	Clear.
	4	16	27	30.10	30.05	NW.	do		Clear.	Clear.
	5	18	30	29.90	29.85	NW.	Brisk		Clear.	Hazy.
	6	18	32	29.90	29.90	W.	do		Clear.	Clear.
	7	19	32	30.00	30.10	NW.	do		Clear.	Clear.
	8	17	41	30.05	30.00	NW.	Moderate		Clear.	Hazy.
☾	9	31	45	30.00	30.05	W.	do		Clear.	Light clouds.
	10	33	36	29.96	29.85	E.	do	.53	Snow.	Rain.
	11	34	41	29.57	29.75	W.	Brisk		Cloudy.	Clear.
	12	36	40	30.10	30.10	NE. E.	Moderate		Clear.	Par. cloudy.
	13	32	33	29.84	29.60	NE.	do	.65	Sleet.	Rain.
	14	17	28	29.85	29.95	W.	Brisk		Clear.	Clear.
☺	15	35	42	29.66	29.66	SW.	Blustering		Cloudy.	Flying clouds.
	16	28	30	29.94	29.80	NE.	Brisk	1.22	Cloudy.	Snow.
	17	26	29	29.40	29.43	NW.	Blustering		Cloudy.	Cloudy.
	18	19	29	29.30	29.54	W.	Moderate		Clear.	Clear.
	19	18	30	29.64	29.64	W.	do		Clear.	Clear.
	20	16	37	29.70	29.73	W.	do		Clear.	Hazy.
	21	20	33	29.86	29.86	W.	do		Clear.	Clear.
☽	22	22	43	29.74	29.65	SE.	Calm	.01	Par. cloudy.	Flurry of snow.
	23	18	22	29.50	29.50	W.	Blustering		Clear.	Clear.
	24	15	25	29.66	29.74	W.	Moderate		Clear.	Clear.
	25	20	43	29.84	29.76	SW.	Calm		Clear.	Lightly cloudy.
	26	20	31	30.00	30.14	W.	Brisk		Clear.	Clear.
	27	26	37	30.26	30.16	E. S.	Moderate		Cloudy.	Snow.
	28	46	52	29.40	30.10	SE. S.	do	2.48	Rain.	Rain.
	29	31	40	29.10	29.90	W.	Brisk		Clear.	Clear.
⊗	30	32	52	30.10	30.10	SE.	Calm		Cloudy.	Clear.
	31	37	39	30.10	30.00	E.	Moderate	.35	Cloudy.	Rain.
		24.45	34.90	29.81	29.86			5.24		

Thermometer. Maximum 52 on 28th & 30th. Minimum 14 on 3d. Mean 32.175

Barometer. Max. 30.26 on 27th. Min. 29.10 on 29th. Mean 29.285

APRIL, 1843.

Moon	Days	Thermometer Sun Rise.	Thermometer 2 P.M.	Barometer Sun Rise.	Barometer 2 P.M.	Wind Direction.	Wind Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	35°	43°	29.60	29.70	NE. W.	Moderate	.15	Cloudy.	Rain.
	2	26	42	30.05	30.10	NW.	do		Clear.	Par. cloudy.
	3	32	47	30.15	30.16	NW. W.	do		Cloudy.	Clear.
	4	34	46	30.10	30.10	E.	do		Cloudy.	Cloudy.
	5	32	40	29.94	29.90	NE.	do	.15	Snow.	Cloudy.
	6	33	47	29.80	29.80	W.	do		Clear.	Clear.
☾	7	37	48	29.90	29.70	W.	Brisk		Clear.	Clear.
	8	40	60	29.40	29.40	SW.	Moderate		Cloudy.	Cloudy.
	9	40	53	29.40	29.36	W.	do		Par. cloudy.	Par. cloudy.
	10	36	46	29.60	29.65	W.	Blusterng		Clear.	Flying clouds.
	11	33	55	29.86	29.86	W.	Brisk		Clear.	Clear.
	12	37	66	29.90	29.94	W.	Moderate		Clear.	Clear.
	13	47	50	30.00	30.00	E.	do		Cloudy.	Rain.
☺	14	51	54	29.54	29.86	E.	do	1.40	Rain.	Rain.
	15	63	62	29.80	29.80	SE.	do		Cloudy.	Cloudy.
	16	52	71	29.87	29.87	NW. SE.	do	.17	Fog.	Rain.
	17	55	60	29.75	29.75	S. SE.	do		Cloudy.	Cloudy.
	18	42	42	29.90	29.90	NE.	Brisk	.30	Rain.	Cloudy.
	19	38	43	30.00	30.00	E.	Moderate		Cloudy.	Cloudy.
	20	40	60	30.03	30.00	N.	do		Clear.	Cloudy.
☽	21	43	63	30.05	30.05	W.	do		Clear.	Clear.
	22	47	72	29.94	29.94	S.	do	.37	Cloudy.	Rain.
	23	54	63	29.76	29.65	S.	do	.27	Drizzle.	Shower.
	24	53	64	29.50	29.50	W.	do	.07	Clear.	Showery.
	25	53	72	29.70	29.76	W.	do		Clear.	Flying clouds.
	26	55	70	29.78	29.40	E.	do		Par. cloudy.	Par. cloudy.
	27	52	73	29.60	29.40	N.	do		Par. cloudy.	Par. cloudy.
	28	45	70	29.80	29.80	W.	Brisk		Clear.	Clear.
⊗	29	55	78	29.85	29.85	W.	Moderate		Clear.	Clear.
	30	48	57	29.80	29.75	E. SE.	do		Cloudy.	Cloudy.
		43.60	56.57	29.81	29.81			2.88		

Thermometer. Max. 78. on 29th. Min. 26. on 2d. Mean, 50.085

Barometer. Max. 30.16 on 3d. Min. 29.40 on 8th 9th 26th 27th. Mean 29.81

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OF

THE FRANKLIN INSTITUTE

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State of Pennsylvania,

AND

AMERICAN REPERTORY

OF

MECHANICAL AND PHYSICAL SCIENCE,

CIVIL ENGINEERING, THE ARTS AND MANUFACTURES,

AND OF

AMERICAN AND OTHER PATENTED INVENTIONS.

EDITED

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JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

JULY, 1843.

Civil Engineering.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On Cast and Rolled Iron Rails for Railways. By JOHN C. TRAUTWINE, *Civil Engineer and Architect.*

Although this subject has recently been much discussed, it does not appear to me that all the facts bearing upon it have been taken into consideration; or that all those which have been examined, have received that degree of attention which is requisite to a satisfactory solution of the question, which of these two materials is the more eligible for common railroad purposes?

It is not my intention here to enter upon an examination of all the various points of inquiry necessarily involved in a detailed investigation of this important question; but merely to draw attention to one or two matters connected with it, which have, as I conceive, either been overlooked by those who have hitherto had the subject under consideration, or have been deemed by them of less moment than I suppose them to be.

It is my opinion that injury has resulted from the fact that those gentlemen who have been most active in discussing the question, have, in too unqualified a manner, expressed themselves in favor of one material, or the other, as preferable *in all cases*, to the entire exclusion of the other: or, in other words, I conceive the question to be not an *abstract* one, but one dependent upon contingent circumstances, by which it becomes so modified as to render the one material preferable, in some cases; and the other, in others. I have myself recommended the adoption of a heavy cast-iron U-rail, on a

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railroad nearly one hundred miles in length, under my charge, from considerations of economy of original outlay, which attended that particular instance, and which happened to be, in that case, one of vital importance; combined with the peculiar difficulty that would necessarily be encountered in fabricating a rolled rail, in a section of country where it would be nearly impossible to obtain, or rather to retain, a sufficient number of experienced workmen for conducting an extensive rolling establishment uninterruptedly. Those who have embarked in such undertakings, under similar circumstances, can testify from experience how much importance is to be attached to this consideration.

Added to these reasons, it was my intention to employ engines with much less weight upon their drivers than is usual on most of our railroads; a point which, as I hope to show further on, has much to do in deciding the question of a choice between cast and rolled rails.

Those who advocate the future rejection of rolled rails "in toto," and the consequent adoption of cast-iron, urge, as the chief argument in support of their views, the splitting, or *lamination*, as it is more generally termed, which experience has shown to take place, to a very serious extent, in the rolled rails used on all our railroads.

Instead of lasting from forty, to one hundred years, which was the term of duration originally predicted for the rolled rail, the supposition being based upon the probable rate of wear, or diminution of material, as deduced from some limited experiments, it has, in fact, on most of our roads doing a heavy business, needed partial replacements within some six or eight years, with a prospect of requiring much more extensive renewals within a few years more.

I conceive, however, that this defect in the rolled rail is not one inherent in the nature of the material, but one admitting of remedies of easy application; and I will proceed to point out in what particulars I think changes should be made in the manufacture of the rolled rail, in order to diminish, if not entirely to remove, its liability to split.

In the manufacture of this rail, as is well known, the process of *piling* is necessarily employed; that is, a number of short, flat, pieces of iron are *piled* on top of each other, and the *pile* is placed in a heating furnace, where it is subjected to a temperature sufficient to bring the several pieces of which it is composed, to the welding point. When the pile has attained this point, it is withdrawn from the furnace, and, without loss of time, is rapidly passed through the successive rolls, by which its pieces are at the same time welded together, elongated, and shaped to the required section of the rail.

But, from want of proper attention on the part of the workmen, the pile is occasionally taken from the furnace before it has reached the welding point; and the consequence is, that the process of rolling does not always unite, or weld together, the several pieces into one mass, so effectually as is necessary for a good rail; and we therefore see that the weight of the engines afterwards separates them, or splits the rail.

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I say the weight of the *engines*, because I am perfectly convinced, from close observation, that it is the great weight borne by their driving wheels, that does most of the injury. I have seen comparatively very little of this lamination in either edge-rails, or the common flat-bar, ⅝ of an inch thick, where horses are used for the motive power, drawing cars having no greater loads than 1½ tons to a wheel; on the contrary, I have seen the five-eighths flat-bar laid even immediately upon *continuous granite sills*, (on which the splitting is more apt to occur than in any other situation,) which have for nearly ten years endured the passage of a very heavy traffic, not drawn by locomotives, without the splitting of a single bar; while the edge-rails on the adjoining parts of the road, over which precisely the same transportation has passed, drawn by locomotives, are split to a very serious extent.

During a personal examination of most of the railroads in the United States, this matter has, among others, received my close attention; and I feel confident that this lamination may be almost, if not entirely, prevented; 1st, (and principally,) by more care in the application of the welding heat;—2d, by so passing the pile through the rolls, that the finished rail shall always consist of laminæ lying parallel to the top and bottom of the rail, as in fig. 1, instead of perpendicular to them, as in fig. 2; and, 3d, by rounding off more boldly the edges of the upper table, or top of the rail. Of the first precaution, we have already spoken. As to the second, it appears to me that the arrangement of the laminæ indicated in the first figure, must, for reasons too evident to require explanation, present more resistance to splitting (though probably less to exfoliation) than that exhibited in the second figure; and this supposition is sustained by the fact, that the splitting does almost invariably occur in lines approaching to the vertical. From this fact, the deduction very naturally follows, that a different disposition of the laminæ would produce a different result; and it is perhaps owing, in a great measure, to the frequent occurrence (probably accidental) of a horizontal disposition of them, that we have not much more splitting than actually does occur.

Fig. 1.

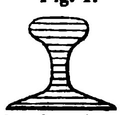
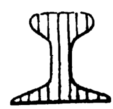


Fig. 2.



I have, it is true, in some rare instances, seen splitting occur in lines forming nearly a semi-circle, transversely of the rail; but these, I am inclined to believe, may be fairly ascribed to a very bad condition of the welding.

The necessity of the third precaution, or that of giving a bolder curvature to the upper edges of the rails, has also been impressed upon me by extensive observation.

It is plain that a great weight acting on a rail, the edges of whose top table are comparatively sharp, as in this figure, (3,) has a tendency to split them off; and when it happens, as it frequently does, that the line of welding of two of the original pieces of the pile lies near either of these edges, experience has shown that, if the welding be at all defective, such a splitting actually does take place.

Fig. 3.

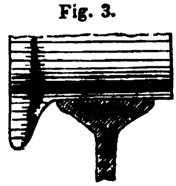


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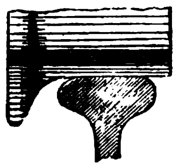
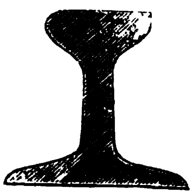
Fig. 4.



But, if we round off these edges, as in fig. 4, it is equally apparent that this splitting tendency must be materially diminished, inasmuch as the cohesion of a much more extended area must be overcome, before a piece can be separated.

I have universally observed so much less splitting in such rails as are boldly rounded at the top edges, than in those whose edges were comparatively sharp, that I have no doubt but that a still further extension of the same principle would be found to contribute considerably towards a correction of the evil, even if no very great improvement should be made in the welding.

Fig. 5.

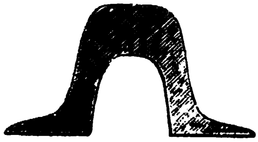


Many of our railroads have rails of the section, (fig. 5,) the upper edges of whose top are dissimilar, one being boldly rounded, while the other is left comparatively sharp. Such rails elucidate my views on this point in a very satisfactory manner; for I have observed that, in every instance, after having been for some time traversed by heavy engines, the outer, or sharp edge splits off badly, while the rounded, or inner one remains comparatively uninjured.

Consequently, this section of rail is objectionable, and I hope soon to see it fall into disuse. It was originally projected to save metal in the outer lip; but I am confident that the pecuniary advantage resulting from any such saving, is far more than countervailed by the diminution of strength attending it.

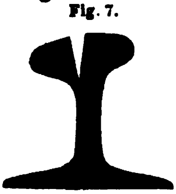
Moreover, there is another disadvantage attached to this section of rail, which is, that when the inner lip becomes worn away, as it will in time, especially on the outer lines of curves, the rail cannot be turned so as to make the original outer lip answer for the inner one. This turning of the rails I have frequently seen resorted to on the sharp curves of much-used railroads, and the rail should, by all means, be made with a view to this facility.

Fig. 6.



A bridge, or inverted U, rail, with the edges well rounded, as in this figure, (6,) will, I suspect, be found to resist splitting better than any form of section in present use; inasmuch as it not only presents a great extent of area of cohesion to be overcome before splitting can take place, but affords *less leverage* for the weight of the engines to act through to overcome it. In some cases, I have seen the T rail split in this manner, (fig. 7,) which proves that, in this section, the welding may, from want of care, be so very imperfect, that no rounding of the edges, alone, could prevent injury.

Fig. 7.



Such disruptions as this, evince very clearly, the utility of diminishing the *leverage* through which the disrupting weight may act.

The ordinary flat-bar furnishes strong evidence of the diminution of splitting arising from more perfect welding, combined with the

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parallelism of the laminæ with the top and base of the rail, aided by an absence of leverage; for it will be found, on examining such of our roads as are laid in part with the flat-bar, and in part with the T rail, that unless the latter be of an unusually strong pattern, it has split much more than the flat-bar.

The foregoing remarks will, I trust, sufficiently explain my reasons for not conceiving the splitting of the rolled rails to be attributable to any defect inherent in the nature of the material itself, but to other causes, which admit of easy remedy; and that, therefore, the principal argument adduced against the rolled rail, is not a tenable one.

Before I conclude this part of our subject, I will advance one suggestion, depending on the propriety of rounding more boldly the top edges of rails, that may possibly be of service on some of our railroads, on which the pattern for the rail to be used has not yet been decided on. It is this, that while we have been gradually increasing the *weight* of our rails, we have unfortunately overlooked the important consideration, *of applying the additional metal to the place where it is most needed.*

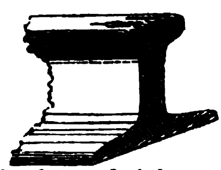
In consequence of this oversight, it will be found that some of our heavier, *improved* (?) rails, split to pieces sooner than some of the lighter ones have done, whose upper table was stouter, and better rounded.

I have had occasion to notice this more rapid deterioration of heavy rails, consequent upon want of just proportion in their parts, in more instances than one, upon very important lines of communication.

Another suggestion, having reference to the weight borne by the drivers of our engines, may not be deemed unimportant.

It is plain that, so long as we retain a top width of rail of about 2¼ inches, we cannot safely place, upon any one driving-wheel, a greater load than can be sustained without crushing, and splitting, by the ends of the rails, upon that width; otherwise the ends of the rails must be crushed, as shown in fig. 8. I shall do no more than allude to this point; my reason for introducing it is, that I feel very confident, from observation, that we have already, in some cases, exceeded the proper limit of load on a driver, warrantable by a top width of 2¼ inches.

Fig. 8.



The success which appears to attend the new *six-driver* freight-engine of that enterprising and skilful machinist, Matthias W. Baldwin, of this city, will go far towards arresting the destruction of our rolled rails. With a weight of but about two tons resting on each driver, she draws, with ease, trains weighing 200 tons over the 45 feet ascents on the Philadelphia and Columbia railroad; and the writer has seen her start, with apparent ease, a train weighing about 150 tons, up grades of 36 feet per mile, when the rails were in an unfavorable condition, being dusty, and slightly wet by a drizzling rain, which began to fall just at the time.

An increase in the number of drivers to our locomotives, which will enable us to diminish the weight borne by each, while, at the same time, it increases the total amount of adhesion, thus enabling us

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to draw heavier trains with less injury to the rails and other portions of the superstructure, I look upon as the greatest desideratum demanded, at the present day, towards perfecting the railroad system.

The advocates for cast-iron rails appear to conceive that material to be free from the danger of splitting on its upper edges, found so objectionable in our present rolled rails. But this is an error; for, unless the upper edges of the cast rail, also, be well rounded, they will be found to be fully as liable to that defect as the rolled rail. The pieces split off will not, it is true, be so long as those which separate from the rolled rail, owing to the granular structure of cast-iron; but their greater number will more than compensate for their difference in length.

From the observations I have made on rails of this material, I find that the splitting, in the case of sharp-edged rails, takes place on the outer edge to a greater extent than on the inner one; and for this reason: the friction of the flanches against the inner edge of the rails has a tendency to wear that edge gradually into a curve, conformable to that which unites the flanch to the tread of the wheel; and this curve operates as a partial protection against splitting, on the principle already alluded to, when speaking of the upper edges of rolled rails.

This action is particularly observable in the outer rails of sudden curves, where the inner edge soon becomes smoothly worn to a bold curve, which acts as a complete preservative against splitting, while the outer edges of the same rails become much injured. On straight lines, the splitting under heavy engines is very serious on both edges, if they be not well rounded; but it is perceptibly greater on the outer one. I have observed the same protective tendency of the outward pressure of the flanches very sensibly exhibited also in some rolled rails which have sharp edges.

By rounding off the edges of the cast rail about as boldly as is done in our best heavy rolled rails, and at the same time diminishing the weight borne by any one driving-wheel to about 1½ tons, I think we should prevent either splitting, or very serious abrasion; and I should not hesitate to employ such a rail, under such circumstances, whenever important considerations should happen to demand it.

We will now glance rapidly at two of the principal objections urged against the cast-iron rail, viz., its brittleness, and its more rapid wear.

Admitting, of course, the former objection, the friends of the cast rail propose to obviate it by the use of continuous wooden bearings. But this expedient, although unquestionably effective so far as it removes the danger of the rails breaking, will, on calculation, be found, in many cases, to raise the cost of the cast-iron track to an equality with one of rolled iron, in which the continuous bearings are not employed; and especially will this remark apply if the bearings be Kyanized.

This consideration neutralizes, in a great measure, one of the principal arguments in favor of the cast rail, viz., its comparative cheapness.

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with, bearing timbers, whether the rail be cast, or rolled, there the proportion of expense is entirely in favor of cast-iron; even when the latter has given to it an increase of weight over that of the former, sufficient to impart to it an equality of strength.

As to the *wear* of cast-iron rails, it cannot, I think, be denied that it is much greater than that of the rolled rails. According to experiments cited in "Wood on Railroads," the comparative wear is shown to be about as 4 or 5 to 1.

He says, (see 3d London edition, page 67:)

"We shall now give some of the results of the wear of cast and wrought-iron rails, with a view of determining the depth of bearing surface.

"In the former edition of this work, we gave an account of two experiments, on the wear of cast and wrought-iron rails, upon the Stockton and Darlington railway, as follows:—*Malleable-iron rails*, 15 feet long, over which locomotive engines pass, weighing from 8 to 11 tons; wagons loaded, 4 tons each; 85,000 tons passed over in a year, exclusive of engines and empty wagons; weight of rail, 136½ pounds; loss of weight, in 12 months, 8 ounces; the breadth of the top of the rail, being 2¼ inches, gives one-tenth of a pound, per yard, per annum; and Mr. Story informs us that subsequent experiments furnish nearly the same results. In determining the premium for the best form of rail, for the London and Birmingham Railway Company, with Professor Barlow and Mr. Rastrick, we found the annual wear, estimated by some of the competitors, at one-sixth of a pound, per yard, per annum. Upon the Killingworth railway, I have had some of the rails, which were weighed and laid down in 1825, taken up and re-weighed; and find the average loss of weight of several rails, to have been eight pounds, for each 15-feet rail, in 12 years, which gives about one-eighth of a pound, per yard, per annum. These rails were laid down at a time when the manufacture of malleable-iron rails was not so well understood as at present; and, on examination, I found part of the loss of weight was attributable to exfoliation on the sides. About 100,000 tons of coals would pass over these rails annually, exclusive of the weight of the engines and empty carriages. Mr. Dixon, the resident engineer upon the Liverpool and Manchester railway, states the wear of the rails upon that railway to be one-tenth of a pound, per yard, per annum; which was determined by taking up three rails, cleaning and weighing them, and then, at the end of twelve months, taking them up again, cleaning and weighing them as before; and this being repeated for two years, the wear was found to be the same.

"We may, therefore, take the wear of the rails to be about one-tenth of a pound, per yard, per annum, which, supposing the whole to result from the wear on the upper surface, will be one-eighty-fourth part of an inch; if the top, or wearing part, of the rail were, therefore, an inch in depth, the rail would wear eighty-four years. The whole of the wear above alluded to does not, however take place

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that the wear by the action of the wheels amounts to one-tenth of a pound, per yard, per annum; if the top, or bearing part, of the rail be made an inch in depth, it will be sufficient for all the purposes required. Any increased depth and weight, which would not be required for above eighty years, would, at compound interest, at the end of that period, amount to a greater sum than it would be convenient to expend for such a purpose, considering the remote period at which it becomes useful."

Again: he says, (page 131)

"Experiments are going on at present, where both kinds of rails, accurately weighed, are laid down, and subjected to the passage of the same quantity of traffic over them; the result of these, so far as they have gone, is in favor of wrought-iron. In the operation of making the cast-iron rails, the surface is partially case-hardened in the casting; this may be seen in all cast-iron rails, extending to a certain depth from the surface. Any experiment, showing the comparative wear, must, therefore, be continued until after the outer hardened surface be worn through; and it is presumed that sufficient time has not yet elapsed to furnish this. We have, therefore, been obliged to reject the data founded on this mode of experimenting, and shall give the result of a different sort of test, more severe, and which, it is trusted, will be deemed sufficiently approximate to justify its presentation to the reader.

"Upon the Killingworth railway we had originally cast-iron wheels upon the locomotive engines; about four years ago, we adopted wrought-iron tires. Now, as we have, in this way, the relative wear of cast and wrought iron upon the wheels which run upon the rails; and as the nature of the action will operate nearly alike, whether upon the surface of the rails or of the wheels, we shall, by that means, have a pretty near approximation to the relative wear upon the rails. In this way, we have a considerably more severe test; as, if we take the quantity of traffic, equal to 2000 tons, passing along the railway daily, and suppose the carriages to convey three tons each, with 3-ft. wheels, the relative wear of the wheels and rails is as 53 : 1, nearly.

"The average wear of the cast-iron wheels was above half an inch in nine months; and, with the wrought-iron tire, the wear of one pair of wheels has been a quarter of an inch in three years, and, with three other engines, one-eighth of an inch in twelve months; making the wear, at least, as five to one in favor of wrought-iron. The actual wear of the rails will not be to the same extent as this, as the engine wheels sometimes slip round, or slide upon the rails, in bad weather. The wear of the wheels of the common carriages will not be so much, for the same reasons; but, although it should be observed, that, from this, we ought not to deduce the actual duration of wrought-iron rails, as, their surfaces being narrower than the wheels, the wear will be, perhaps, more than proportionably greater, yet the relative

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wear should, however, remain the same. We now give the following experiment made on the Stockton and Darlington railway:

"Cast-iron rails, 4 feet long, over which wagons only pass, weighing four tons each, when loaded; 86,000 tons passed over in a year, exclusive of wagons; weight of rail, 63 lbs.; loss of weight in twelve months, 8 oz. The loss of weight in malleable-iron rails was, in the same period, 8 ounces for 15 feet length; the same quantity of goods, 86,000 tons. This will give the difference of wear 15 : 4 in favor of wrought-iron rails.

"These experiments show that, if rails of the proper degree of strength be used, the durability is decidedly in favor of wrought-iron rails; and we have before observed, that, in rails properly manufactured, none of the exfoliation, or oxidation, originally dreaded, exists."

And again, in his appendix, (page 729,) he gives the following experiment:

"On the 10th of May, 1831, on the Liverpool line, a malleable-iron rail, 15 feet long, carefully cleaned, and weighing 177 lbs. 10½ oz., was laid down. On the 10th of February, 1833, the same rail was taken up by Mr. J. Locke, then resident engineer on the line, and well cleaned as before, and weighed 176 lbs. 8 oz. It had consequently lost, in twenty-one months, a weight of 18½ oz. The number of gross tons that had passed on the rail, during that time, was estimated at 600,000. Thus we see that with so considerable a tonnage, and with the velocity of the motion on that railway, the annual loss of the rail was only $\frac{1}{268}$ of its primitive weight; so that it would require more than a hundred years to reduce it to the half of its present strength."

In the United States no experiments have, I believe, been made to determine the comparative wear of the two kinds of rails; but, so far as my personal observation extends, I should have assumed a proportion at least as great as that deduced from experiments by Mr. Wood.

Having shown what authority may be adduced in proof of the statement that cast-iron rails wear much more rapidly than rolled ones, (a fact which some of the advocates for the cast rail refuse to admit,) I shall close this paper without entering into any calculations of the comparative outlays attending the wear of the two materials. These, any engineer may make for himself in a few minutes, having the foregoing data, and the cost of cast and rolled iron at the time and place where they are required to be used.

I have been induced hastily to throw together these few remarks on this important subject, in order to rectify an erroneous impression that has arisen from my recommendation of a cast-iron rail in one particular instance, that, therefore, I considered it preferable to the rolled rail in all cases.

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Memoir upon the Stability of Revetments, and of their Foundations. *By* M. Poncelet, *Chef de Bataillon du Génie. Translated from "No.* 13 *du Mémorial de l'Officier du Génie," by Captain* John Sanders, *Corps of Engineers.*

[continued from vol. v, page 371.]

Upon the origin of the practical rules for calculating the thickness of retaining walls.

84. The year 1687 is the date usually assigned to the official transmission of the general profile of Vauban to the various fortresses, though it is quite probable that it was some years sooner. It was only four years later, in 1691, that Bullet, in his *Traité d'architecture pratique,* proposed a rule, not based upon the results of experience, but upon a mechanical theory, which, although very imperfect, nevertheless appears, from the celebrity of the author, and the great number of editions of his book, to have been adopted by many architects and constructors. This rule is equivalent to taking the thickness of vertical terrace walls about equal to the 0.35 of the height, and is based upon the supposition of the earth and masonry being of the same density.

85. In a manuscript memoir of 1716, dated at Metz, and which is to be found in the *Dépot des fortifications,* Buchotte, a military engineer, supposes the natural slope of earth to be 45°, and its specific gravity to be equal to two-thirds of that of masonry; which leads him, by a train of reasoning confined solely to the hypothesis of sliding, and of a coefficient of friction equal to unity, to make the weight of the wall, which was supposed vertical, equal to two-thirds of that of a prism which answers to the natural slope of the earth; or, which amounts to about the same thing, to make the thickness of this wall equal to one-third of its height. Querlongue, in another manuscript note of 1743, has, nevertheless, observed that this rule (of one-third of the height) was only applicable to *mean* earth and masonry, and that the proportion should change with the ratio of the densities. This, however, did not hinder several following engineers, and Gauthey among the number, who, in 1785, undertook to establish the uniform correctness and generality of this same rule.

86. From the estimation justly given to his other works, and by the results of the experiments with which he has accompanied his theoretical views in a memoir published at the time designated, Gauthey has especially contributed to cause this rule to be considered as one of universal application, whether as to the effects of sliding, or as to those of rotation. For if, on the one hand, he takes the density of the earth equal to four-fifths of that of the masonry, which may be considered as a limit; on the other hand, he admits in principle, from the result of experiments erroneously interpreted, that the thrust from the pressure of the earth is independent of the angle of its natural slope, and is nearly equal to the fourth, or third, of the weight of the prism at 45°, which we may look upon as establishing a sort of com-

pensation of errors. But, to show how very erroneous similar results, formed into practical rules, must be; and, at the same time, to undeceive those engineers who still oppose the adoption of the new theories which emanate from the learned researches of Coulomb, it will suffice to remark, that, according to the spirit of the empirical rules under consideration, the resistance of a vertical wall, where the retained earth was not embanked above its top, would only exceed by a tenth, or would even simply equal, the action of the pressure of the earth—evidently an absurd consequence.

What it is here essential to be established, is—1°. That the rule of the thickness being equal to one-third of the height, originated in imperfect theories, and not from a clear and judicious experience;—2°. That it is defective; and, above all, errs in this, that it overlooks the actually given quantities on which a correct solution of the question must depend (24).

87. We have not referred to Belidor, because his method, although founded upon a more advanced theory, but equally questionable in principle, has never been generally adopted as a practical rule by engineers. But, as to that of Vauban, relative to revetments, or to demi-revetments, the opinion that it was principally founded upon military and practical considerations, without reference to any mechanical theory, being quite generally entertained; we think that we should here establish the contrary, and, at the same time, show what are the principles which might have guided the author in the discovery of his rule, which is often criticised, but seldom deviated from in practice.

Vauban, in his *Traité de la Defénse des Places*, after treating of the various masonry revetments, adds: "Moreover, we should not expect a great resistance from these revetments, for they are not made with the view of resisting cannon for any length of time, as many seem to imagine, but to sustain the rampart, and to prevent an escalade, since it is certain that, if a battery of eight or ten pieces is placed upon the parapet of a covered way, with the design of making a breach in the face of the opposite bastion, and if it is well served, then, in less than forty-eight hours, it would open this face to its foundation, and would penetrate to the earth beyond it, and, however solid the revetment might be, it would overturn it," &c.

It is thus very clear that Vauban attached no military importance to the use of counterforts; and this result, derived from a long experience in sieges, has, since then, been fully confirmed by the recent experiments made at Metz, under the direction of Captain Piobert, of the artillery. A summary of these experiments will be found in his *Traité d'Artillerie théorique et pratique.* Indeed, we see, from them, if the counterforts should remain standing, by being in part engaged in the earth, after the fall of the wall, and should thus contribute to retain the earth, that it would only require some volleys of shot and shell to overthrow this earth entirely, and thereby to lessen the slope so as to render it practicable for the assaulting party. This fact, at the same time, proves that profiles, with long counterforts,

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and with relieving arches, either horizontal or vertical, do not possess the military advantages that writers have erroneously attributed to them, from the commencement of the last century.

But Vauban is still more explicit in the instructions with which he accompanied his general profile, wherein he says: "This profile is accommodated to various heights of walls, is proportioned with reference to the weight of earth which they have to retain, and has been tested in the building of more than four million cubic yards (500,000 *toises cubes*) of masonry, at 150 different fortresses:" a phrase which evidently proves that this same profile was not simply the result of a long practice, but rather the consequence of rules and principles which must have preceded its application in military constructions.

Finally, the last article of these instructions being as follows, "these profiles are only proposed for masonry which has to sustain great weights of newly embanked earth, and not for that which is built against the face of an excavation where the earth has never been moved, which is generally the case with the revetments of ditches of fortifications," &c., we should conclude from it, that, under such circumstances, Vauban found the thickness furnished by his general rule to be too great. But this will not suffice to explain the motives which led him to reduce to four, or even to three, feet, the thickness at the top of counterscarps and gorge walls, in the place of five feet, which is given by the general profile, any more than it will, the reduction of the exterior slope to one-sixth. We must conclude, that Vauban not only had confidence in the solidity of his general profile, but that he knew how to introduce a judicious economy in constructions, when either the localities, or given quantities of the question, would authorize it.

88. With regard to the criticisms of this same profile by Buchotte, Couplet, Belidor, and all those who have since undertaken to investigate this question, they bore chiefly upon the apparent defect, in the proportions of the thickness and height, which makes the thickness of walls over ten metres high, too slight, and that of those under too great. This reproach appeared so much the better founded, as, in consequence of the false hypotheses then admitted upon the value of the pressure, and of the compensation of the errors which took place in the calculations; they obtained, as we have seen (85 and 86), proportions which corresponded with those of the general profile, for walls of the mean height of ten metres, and which they very naturally attributed to their having got into conditions bordering on a strict equilibrium. The fact is. that when we take at all into consideration the weight of the parapet, the influence of which decreases as the height increases, and also the effect of the counterforts, which, on the contrary, increases very rapidly with this height, we never arrive at any marked difference in the thickness. Besides, we ought not to be astonished that the rule of Vauban should only have received such slight changes, notwithstanding the numerous attacks of which it has been the object, as we shall show that they were not based upon correct mechanical principles.

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Foundation of the rule of Vauban.

89. In examining attentively the constitution of this profile for the case of ordinary parapets, we perceive distinctly therein an intention to make the thickness of the masonry, following the theory of the wedge, or inclined plane, increase proportionally to the height of the retained embankment, which is composed of a variable part equal to that of the revetment, and of a constant part depending upon the height of the parapet. Only that Vauban, instead of taking the height of the parapet simply equal to 2 or 2½ metres, has attributed a much greater value to it, doubtless with the intention of securing to the revetment an excess of stability, or thickness, independent of its proper height, and sufficient to guard against various accidents, such as temporary or permanent additional loads on the ramparts, scaling of the face of the wall, penetration of projectiles, &c.; circumstances which do not in fact change with the height of the revetment. Such an hypothesis seems very rational to us, and more conformable to the true laws of physics, than that by which some engineers of our day give an excess of stability, or thickness, to retaining walls, which, in place of being constant, increases proportionally with the height, as if the causes of destruction ought themselves to increase in this proportion.

90. At all events, it is very worthy of remark, that the idea of a constant additional load appeared natural enough for Couplet to adopt it in the "*Mémoires de l'Académie des Sciences,*" of 1727, as proper to secure the necessary excess of stability to revetments; and that an anonymous author, in an unpublished memoir among the papers in the Dépôt of Fortifications, should conceive that this constant additional load might really have been the fundamental principle of the profile of Vauban. But the complicated calculations and imperfect theories of these authors, were not such as to set the matter in its true light, or to cause the consequences of it to be admitted by engineers. This principle will, on the contrary, appear nearly incontestible, at least with regard to the body of the masonry, if we compare the practical formula of numbers 23 and 38, with this, $e = 0.18\,\mathrm{H} + 1.64$ ms., which likewise represents (74), on the hypothesis of rotation, the thickness of vertical walls of the same stability with full revetment of Vauban.

In fact, if, in order to bring it to the case of strict equilibrium, we should divide the factor, 0.85, of the first of these formulas, by 1.459, the square root of the coefficient of stability 2.13, which enters implicitly into it (23); and should, moreover, suppose $f = 1$, or $\alpha = 45°$, $p = \frac{2}{3} p'$ hypotheses universally adopted in the time of Vauban, it becomes

$$e = 0.2\,\mathrm{H} + 0.2\,h,$$

and gives results not perceptibly differing from those of the preceding, when we suppose that h is equal to 3.2 metres for the lowest walls, and to 7.4 metres only for the higher revetments, such as 19 or 20 metres, for example; which is equivalent to taking a mean term, h

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rapet,) to giving a constant additional load of earth 5.8 metres high, which corresponds to an additional thickness of masonry 0.2×5.8 m. $=$ 1.16 m. This we should (according to the assumed views of Vauban) consider as necessary to secure to the body of the masonry a proper excess of stability independent of its height.

91. What is most singular in this similarity of results, is, that the value $h = 7.8$ m., coincides almost rigorously with that of the point of intersection of the inner and outer faces of an ordinary scarp; and that the same coincidence, also, very nearly occurs in the case of demi-revetments, when we compare the approximate formula $e = 0.2\ (\mathrm{H} + h + 5.8\ \mathrm{m.})$ with this, $e = 0.18\ \mathrm{H} + 0.202\ h + 1.24$ m., which is obtained (74) from the transformation of the general profile of Vauban.

It is evident that such coincidences are not the result of mere chance, and that they justify the assertion, not only that Vauban determined the thickness of his revetments on the hypothesis of a constant additional load of earth of about 5.8 metres in height, but, besides, that he had recognized, through the range of ordinary practice, the correctness of the rule which makes the thickness of vertical walls, with a parapet covering their summit, sensibly proportional to the entire height of the earth to be sustained. However, as we have only, so far, had under consideration the body of the masonry of the general profile, it remains for us to show that the same things occur when we introduce the action of the counterforts in the calculation of the moment of stability; for that purpose we shall assume, with all the old engineers, that these counterforts turn in a common mass with the wall, around the outer edge of its base.

92. The extent back of the counterforts from the wall being, for ordinary revetments, expressed by $0.2\ \mathrm{H} + 0.65$ m., and their width at their junction with the wall by $0.1\ \mathrm{H} + 0.65$ m., which gives for that at the end $\frac{2}{3}\ (0.1\ \mathrm{H} + 0.65\ \mathrm{m.})$; we find, for the general expression of the required moment, reduced to a running metre of the profile, and in supposing the thickness at the cordon to be about 1.625 metres, and that the counterforts are distributed along at distances from centre to centre:

1° of 5 metres apart, (a') $0.000953\ \mathrm{H}^4 + 0.029296\ \mathrm{H}^3 + 0.40833\ \mathrm{H}^2 + 1.456\ \mathrm{H}$;

2° of 6 metres apart, (b') $0.000794\ \mathrm{H}^4 + 0.026638\ \mathrm{H}^3 + 0.39444\ \mathrm{H}^2 + 1.433\ \mathrm{H}$;

formulas in which the term in H^4, always very small with reference to the sum of the others, as long as H is less than 12 metres, is introduced because, on the one hand, Vauban has been obliged to make the width of the counterforts increase with their height, so as to secure them against rupture by a resistance which, in itself, increases with their weight; and, on the other hand, he wished to preserve an invariable distance between the axes of these counterforts.

If we should now likewise seek the moment of a vertical wall of the same height H, and of a thickness which may, in general, be ex-

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pressed by the formula $e = k\,(H+h)$, k being a number to be determined, and h continuing to represent the height of the parapet, augmented by its load of stability, we shall obtain for its expression,

$$\tfrac{1}{2}\,e^2\,H = \tfrac{1}{2}\,k^2\,(H+h)^2\,H = \tfrac{1}{2}\,k^2\,H^3 + k^2\,h\,H^2 + \tfrac{1}{2}\,k^2\,h^2\,H,$$

in which the term in H^4 is alone wanting.

We should not expect that the numerical coefficient of the formula $e = 0.2\,(H+h)$ of number 90, would satisfy the condition, since it only refers to the stability, itself, of the mass of the masonry; therefore, in making $k = 0.2$ and $h = 7.8$ m., we obtain only, for the corresponding value of the moment,

$$0.02\,H^3 + 0.32\,H^2 + 1.28\,H.$$

But, on the contrary, we shall make the results almost rigorously coincide, by taking $k = 0.2357$, $h = 7.2$ metres; for we shall then obtain the moment,

$$(c') \qquad 0.027798\,H^3 + 0.40000\,H^2 + 1.440\,H,$$

which is about a mean between those in question, if we omit all consideration of the term in H^4.

93. It is, besides, easy to perceive why we do not again fall upon the height of the load, $h = 7.8$ m., of the preceding case; for the solidity of the connexion, and the economy in the expenditure, having brought about the giving to counterforts a thickness which increases with the height, it has also been necessary, as is shown by the drawings of the *tracé* of the general profile, that the planes passing through the edges of their bases should converge at less heights above the summit, than that which belongs to the scarp itself, so as to lessen the influence of the term in H^4, which, in the expression of the moments, arises from this increase of thickness.

Nevertheless, if this explanation is not satisfactory, and it is desired that we should confine ourselves to the values $h = 7.8$ metres, and $k = 0.2357$, we shall find for the moment of a vertical wall, whose thickness $e = 0.2357\,(H + 7.8\text{ m.})$,

$$(d') \qquad 0.027778\,H^3 + 0.433337\,H^2 + 1.690\,H;$$

and then it will also be necessary to admit that it entered into the views of Vauban to correct, in part, and for the mean height $H = 10$ metres, the influence of the term in H^4. We actually find, on this hypothesis, for the value of this last expression 88.00, and for those of (a') and (b'), to which we compare it: 94.22 and 83.35 respectively.

Whichever we may adopt, the consequences to be drawn from the result remain nearly the same, with regard to the principles which must have guided Vauban in the composition of his profile for ordinary revetments.

94. As to the rule of demi-revetments, it is very naturally decided on by this consideration, that it will only be necessary in the expressions $E = 0.2\,H + 1.625$ metres for the thickness at the base of this profile, and in $0.1\,H + 0.65$ m., $0.2\,H + 0.65$ m., &c., for the horizontal

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height H whatever, surmounted by a parapet of earth, of a mean and effective height h above the cordon. For, in likewise making this substitution in the analytical expressions of the moments (a'), (b') and (c'), or (d'), which renders them applicable to demi-revetments with the outer face either inclined, or vertical, they will continue to correspond together to the same degree of approximation. A result evident in itself, as soon as we admit, for vertical demi-revetments, the approximate rule

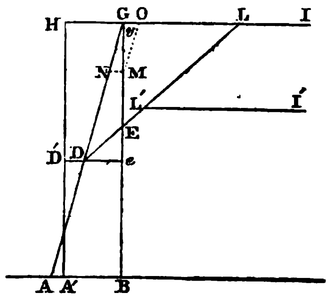
$$(e') \qquad e = 0.2357\ (\mathrm{H}+h+5.5\ \mathrm{m.}),$$

5.5 m. here representing the mean additional load requisite for stability.

These approximations would be sufficient to prove, rigorously, that the rule of Vauban belongs to a more advanced mechanical theory than that of the authors who have endeavored to criticise it. But I shall endeavor to put it in a still clearer light, and to trace even the train of ideas by which Vauban might have arrived at it.

Principles admitted by Vauban in the establishment of his general profile, and their consequences.

95. Let A'BGH be a vertical wall retaining the terrace BGI, on a level with its summit; from the principle of the wedge, or inclined plane, the pressure upon any height GM whatever, or the horizontal effort necessary to retain the weight of the prism of earth GMO upon the slope OM, which is at any angle v whatever from a vertical, will be, in neglecting friction,



$$p \times \mathrm{GMO}\,\frac{\mathrm{GO}}{\mathrm{GM}} = \tfrac{1}{2}p + \overline{\mathrm{GO}}^2 = \tfrac{1}{2}p\ \mathrm{tang.}^2\, v \times \overline{\mathrm{GM}}^2;$$

which demonstrates that the pressure increases, as in liquids, proportionally to the square of the height GM, and that all the difference is simply in the factor tang.^{2} v, which, in liquids, becomes unity.

This single consideration was enough to satisfy Vauban, 1°, That the centre of the pressure is at about one-third of the height GM of the prism, measured from the point M; 2°, That the triangular form ABG of the profile of masonry, is that which secures the equilibrium of every part GMN, whether for the case of rotation, or of that of sliding; 3° and lastly, That the angle GMO or v of the prism of pressure, could be neither zero, which is evident, nor an angle of 45°, that assumed as the natural slope of mean earth, since it would reproduce the hypothesis of fluidity, for which likewise tang. $v = 1$, but rather an

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intermediate angle, a half for example, or such that $GO = \frac{1}{2} GM$, tang. $v = \frac{1}{2}$; which Belidor, as far back as 1729, trusting to reason and the results of experience, desired to make it.

According to that, if we consider the equilibrium of any triangle ABG of masonry whatever, under the action of the pressure $\frac{1}{2} p$ tang.^{2} $v \times \overline{BG}^2$, acting against the whole extent of its height, we shall especially obtain, on the hypothesis of rotation,

$$p' \tfrac{1}{2} AB \times BG \times \tfrac{2}{3} AB = \tfrac{1}{2} p \text{ tang.}^2 v \times \overline{BG}^2 \times \tfrac{1}{3} BG;$$

from whence

$$AB = \text{tang. } v \sqrt{\tfrac{1}{2} \frac{p}{p'}} \times BG.$$

Taking, with Belidor, tang. $v = \frac{1}{2}$, instead of $v = \frac{1}{2}\, 45°$, and tang. $v = 0.4142$, according to the latest and truest theories; and making moreover, $p = \frac{2}{3} p'$; this equation will give $AB = \frac{1}{2} \sqrt{\frac{1}{3}}\, BG = 0.2887\, BG$, in the place of $AB = 0.239\, BG$, which we would obtain from the second value of tang. v.

96. The first of these solutions giving to the wall an outer slope of nearly $\frac{3}{10}$ upon a vertical, Vauban ought not to have admitted it, although the constructions of his time offer examples of scarps with slopes of $\frac{1}{4}$; and in limiting himself to that of $\frac{2}{10}$, he has sacrificed a part of the advantages inherent to the profile of equal resistance; advantages which he has, however, regained by adopting a system of counterforts, properly distributed in order to supply that which was wanting in the moment of the wall.

Observing, now, that the ordinary form of the superincumbent mass of earth sustained by a revetment, such as ABCD, for example, is not CGI, but DELI, which takes away the pressure from along all the height GE, and renders the part above the cordon CD entirely superfluous for retaining the earth: we might suppose that Vauban, in comparing the moment of the prism of masonry CDG, with reference to the point A, to the sum of the moments of the pressure against GE, and of the prism of earth CDE, must have allowed them to be nearly equal, which comes to about the same thing as regarding the mass of masonry ABCD as being virtually in a state of equilibrium under the action of the mass of earth BELI. We could readily explain, on this hypothesis, and on that of a constant additional load for stability, which we shall represent, for example, by I'L'LI, the general disposition of the profile of ordinary revetments and demi-revetments. But a comparison between the moment of the wall ABCD, and that of this profile with its counterforts, does in no manner sustain such a suspicion; and we are forced to return to the consideration of a vertical wall, backed in with earth to a level with its summit, to discover the real motives and actual point of departure for the rule of Vauban.

97. Then let A'BGH be a rectangular profile of masonry, subjected to the action of the pressure of earth along its whole height BG, we shall have, for the condition of equilibrium,

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and if we suppose, as heretofore, tang. $v = \frac{1}{2}$, $p = \frac{2}{3} p'$, we shall find $A'B = 0.2357$ BG, which gives,

$$e = 0.2357\ (H + h)$$

h designating the total height CG of the superincumbent mass of earth. For the case of sliding upon the base of the wall, we should have, (f' being the coefficient of friction,)

$$f' p' \times A'B \times BG = \tfrac{1}{2} p, \text{tang.}^2\, v \times \overline{BG}^2, \text{or } A'B = \frac{p}{2f'p'} \text{tang.}^2\, v \times BG.$$

In taking, as was done in the time of Vauban, $f' = \frac{1}{3}$, $p = \frac{2}{3} p'$, tang. $v = \frac{1}{2}$; this formula coincides very nearly with the preceding one. Thus, in this method, the equilibrium would also be secure on the hypothesis of the wall sliding upon its foundation.

Now, it will be observed that the former formula, when we replace h in it by ($h + 5.5$ metres), coincides exactly with (e') the one obtained in number 94, for the thickness of vertical revetments of the height H, which have the same stability as that of Vauban with counterforts. We can, therefore, with propriety, conclude that he had discovered, by geometrical trials made directly upon the given quantities of the problem, the kind of compensation of errors which takes place in such cases; that is to say, for a vertical revetment A'BCD', retaining a superincumbent load DLI; this compensation is between the moment of the mass of masonry CGHD', which is thrown out, and that of the triangle of earth CDE, (the weight of which is added to the wall A'BCD',) together with that which would arise from the diminution of the pressure against the whole or primitive height BG, at least as long as CG does not attain twice the height BC.

98. Although the verification of this result may be rather delicate, particularly in regard to the determination of the length of the arm of the lever of pressure, it is not a sufficient motive for believing that Vauban did not arrive at it, because this determination depends only upon the most elementary geometry. If any one doubts it, it will suffice to read the writings of the old authors, such as Belidor, who have endeavored to investigate this question in the case of loads having the form of a parapet. It will not, perhaps, be useless to remark, on this subject, that, if we adopt for the measure of the pressure of earth against a rectangular revetment A'BCD' (fig. 5), the expression $\frac{1}{2} p$ tang.^{2} $v \times \overline{BG}^2$, referred to the total height of the earth to be retained, and take for the reduced length of the arm of the lever of pressure, one-third of the height BC only, we would again exactly fall upon the formula $A'B = 0.236$ BG; because that would, as above, give the equation of equilibrium, $p \times \frac{1}{2}\, \overline{A'B}^2 \times BC = \frac{1}{2} p$ tang.^{2} $v \overline{BG}^2 \times \frac{1}{3}$ BC, or $A'B =$ tang. $v \sqrt{\frac{p}{3p'}}$ BG. Vauban might easily have dis-

covered that the necessary compensation takes place in the errors arising from these two hypotheses.

99. Besides, whatever may be the opinion entertained of this explanation, it will none the less be proved, that, on the hypotheses generally assumed by old engineers (75) upon the function of the counterforts, the stability of the profile of Vauban is found, as far as regards rotation, to be essentially equal to that of a vertical wall of the same height H, and with a thickness given by formula (e') of no. 94. Now, this furnishes at once (72) the means of transforming this profile into an equivalent one without counterforts, and with any exterior slope whatever.

In those cases where the explanation is adopted, we must conclude from it, that, if the rule of Vauban errs in any point, it evidently does not in theory, but rather from its attributing to tang. v, or to k (92), values 0.50 and 0.236, a little too great, which it would be more exact to replace by about 0.414 and 0.2; nor, moreover, from increasing the thickness in a proportion so much the more, as the height of the superincumbent mass ($h+5.5$ m.) is greater with reference to that of the wall; but really from depending on the hypothesis of *mean* earth and masonry.

100. Besides, if, while admitting the principle of a constant additional load for stability, in height equal to 5.5 metres, we should wish to generalize the rule of Vauban, nearly as he would himself have done it, it will suffice (97) to replace the coefficient 0.236, by the expression

$$\tfrac{1}{2} \text{ tang. } \alpha \sqrt{\frac{p}{3p'}}$$

in which we should also, for greater exactness, and in conformity with the theory of Coulomb, put tang. $\tfrac{1}{2}\alpha$ in the place of $\tfrac{1}{2}$ tang. α.

Then we should take

$$e = \text{tang. } \tfrac{1}{2}\alpha \sqrt{\frac{p}{3p'}} (\text{H} + h + 5.5 \text{ metres}),$$

for the thickness of vertical revetments, or the thickness (72) at one-ninth of its height of a revetment, without counterforts, of the same stability, but with its outer face inclined.

But, in making use of this formula, we are to recollect, that, independently of the hypothesis of a constant additional load of 5.5 metres for stability, which, even according to the remark of Vauban (87), would not answer for counterscarps and gorge walls of military works, it will still lead (21 and 35) to an excess of thickness in the case of parapets preceded by wide berms, and in that of low demi-revetments retaining very high embankments. In such circumstances, it will tend to economy, while fully maintaining the principle of stability of Vauban, to calculate the thickness by means of equations (s), (t), (u), and (s') of the 26th and following numbers, in which we must substitute 1 for δ and ($h+5.5$ metres) for h.

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versity College.

[Continued from Vol. V, Page 377.]

SECOND COURSE.—LECTURE VIII. ON CURVES.

In continuation of the subject of curves, Mr. Vignoles explained that in many cases it was impracticable, or inconvenient, to apply, on particular ground, the approximate rule given in the last lecture, of setting out curves chain by chain, or other short lengths, making each the side of a regular polygon, the set-off being constant. In that method the given length was strictly a secant, and not a tangent, to the curve. Another formula was more generally applicable, and sharp curves on hill sides, through thick woods, had been quickly and accurately set on therefrom. It was this: $offsets = radius - (radius - tangent)^{\frac{1}{2}}$; the demonstration of this was given, and illustrated by a diagram. For the field, tables calculated beforehand, for the greatest number of usual curves, should be prepared; but, on the occurrence of any peculiar cases, the calculation could be very readily made, with the help of a pocket table of natural sines. The Professor then recapitulated some of the leading points that had been gone over in detail at the last lecture, observing that, on the three principal expedients for counteracting the injurious effects of curves, the usual measurements might be easily remembered, viz., half an inch for the "cone" of the tread of the wheel; one inch as a *maximum* amount of "play" of the wheels between the rails, (it being disadvantageous to allow too much play;) and one inch for the extreme elevation of the outer rail in laying the way, that being the measure due to a velocity of 25 miles an hour, on a curve of half a mile radius. Mr. Vignoles then observed that the "cone" being given to the wheels on account of the curves, when the line of road was perfectly straight, this conical formation of the tyre was not required, and the general disadvantage of such a form of wheel, not bearing upon the whole face, or upper button, of the rail, preponderated. It had, therefore, become customary to incline the rail, to meet the cone of the wheel, and this should always be done, both on straight lines, and on curves whose radii are not small. This inclination of the surface of the rail is obtained by casting the receiving chair, accordingly; on rails, having a continuous bearing on longitudinal sleepers, or bearing direct on cross timbers, without the intervention of chairs, the wood is cut to the requisite angle; or the inclination is sometimes given to the rails in passing through the rolls. Without this precaution of inclining the bearing surface of the rail to meet the cone of the wheel, the edge rapidly wears, and the laminæ of iron peel off in strips, more or less, according to its quality; and there is no more critical test of the perfection of rolled iron rails, than the manner in which the button edges go through this ordeal. With the above precautions of "cone," "play," and the elevation of the outer rail, the resistances opposed by curves to a single carriage may be considered to be annihilated; but

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when the trains become very long, there must, of necessity, be a considerable lateral action and grinding, from the change of direction of the original drawing force through a number of carriages; but Mr. Vignoles stated that, although no conclusive experiments had been made to show the exact amount of resistance from this cause, his own observations and experience led him to conclude that the degree of curvature on railways might be safely extended further than they have hitherto been laid down on principal lines.

Mr. Vignoles referred to former observations of his, that the public would be better accommodated by more frequent departures of smaller trains, and that with such trains the curves would be of still less importance, adding that it could only be by the introduction of greater curvatures to save expense; and, as he had repeatedly argued for the same reason, by the adoption of steeper gradients, that the benefits of railway communication could be extended through many districts, and to the more distant parts of the country, as on the most economical principles of construction. Mr. Vignoles referred to the report of the Irish Railway Commissioners, and to the works of Mr. Wood, M. de Pambour, Lieut. Lecount, and other writers, for further details on curves, observing, in conclusion of this part of the subject, that where curves are so quick as to require it, especially in crossings, the additional precaution of guard rails becomes expedient.

In adding a few words on the subject of coupling carriages together in a train, the Professor insisted strongly on the draw-boys being always in the centre, and observed that, as a general rule, the connecting links should be screwed up as stiff as possible consistently with the curves of the railway, as, otherwise, the carriages are apt to swing. He mentioned that the best coupling was that of Mr. Henry Booth, the talented manager of the Liverpool and Manchester railway from its very first origin. But, as a general form of combining the draw-boys and buffers on a central rod, or tube, with spiral springs acting solely from the centre, Mr. Vignoles spoke in the strongest terms of the apparatus of Mr. Thomas F. Bergin, the manager of the Dublin and Kingstown railway, on which line they had been used with advantage for a number of years.

LECTURE IX.—ON TUNNELS.

In proceeding to treat of the subject, which might be termed that of the great works of art, to be introduced in the formation of roads, or canals, but particularly of railways, Mr. Vignoles said that it would not be possible in the lecture room to go into the details of the construction, but that he must limit himself to general principles. The rules for consideration when such works ought to be adopted, were sufficiently simple; for example, to determine where tunnels should be substituted for open cuttings, or viaducts for embankments. The French engineers, who are in general very much better mathematicians than we are, and, probably, from that very circumstance, more inclined to be theoretical, are much in the habit of introducing formulæ, which, often very useful, are not always readily applied by the practical men of this country. Supposing it to be required to deter-

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canal,) it is advisable to begin to tunnel, instead of continuing a simple excavation—that is, the point where it becomes as cheap to tunnel as to cut open; for such a case, the following formula is given by an eminent French engineer: Let x=depth of cutting; l=breadth of road, railway, or canal, on the traveling surface; a=depth of bed, of road, or railway, to be first excavated, and afterwards filled with road material, or ballast; or depth of canal below the water-line; $\frac{x}{m}$= slope of excavation; p=price of the cutting per cubic yard. The expense of excavation per yard forward of the sectional area of any cutting, will consequently be $ap \times p\ (l \times \frac{x}{m} = x$; and when this price exceeds the price per lineal yard forward of tunneling, the latter is cheaper, supposing the given prices to cover all risk and contingencies in each case. But, as circumstances are continually varying, the English engineer so repeatedly finds that he has to modify—and perhaps finally abandon—the general theoretical rule, and fall back on his own experience, and that of the contractor he may be disposed to employ, that, although he may occasionally resort to such a formula as an approximation, he ceases to employ it in practice, and obtains the sectional area of the given cutting in superficial yards, by simple mensuration, and multiplies it by the price. All the complex conditions involved by slips, faults, water, and the numerous incidental occurrences in great works, to occasion unforeseen expenses, render prices uncertain, and prevent any fixed general rule; and it is only when the materials and probable contingencies are perfectly well known, that the element of cost can be safely introduced into the mathematical formula. For dry, indurated sands, gravel, sandstone rocks, &c., calculations may be made within probable limits of error; whereas, in many instances where the theoretical rule and general opinion, even of those sufficiently experienced, would recommend tunneling, it has been tried in vain, abandoned after great expense in contending with water, and recourse had, after all, to open cutting. The average cost of tunneling, upon the principal railway lines, as actually executed, appears to be about 60*l.* per yard forward, in some instances as much as 100*l.*, especially when driven forward in reckless haste, and in attempting to sink shafts, or drive drifts, without due consideration as to the quantity of water in the various strata, or the means of at once grappling with the difficulties of drainage, or pumping. With great facilities, favorable material, and not too much hurrying, the same area of tunnel has been driven for as little as 20*l.* per yard forward. In round numbers, and on an average, the sectional area of the ordinary tunnel for a double line of railway, to be worked by locomotive engines, may be called fifty superficial yards when finished, or within the ring of brickwork, or masonry, if lining were required; in this latter case, the sectional area of the opening to be excavated may be assumed as about eighty superficial yards. Mr. Vignoles observed that, for future tunnel operations, with the benefit

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of past errors and experience, by avoiding undue haste in execution, and with sufficient caution and activity, 40*l.* per yard forward for tunneling may be taken as an average approximate fair price. Now if it were wished to compare this expense of tunneling with the cost of open cutting, the Professor observed that, from his experience, which had been very considerable, in removing earth in large quantities, he was not disposed to put a less price than that of 1*s.* per cubic yard for removing material for deep excavations, especially when this price is to cover contingencies of slips, &c.; with such a price, then, an open cutting 55 ft. deep, roadway 24 ft. wide, and soil requiring slopes of two horizontal to one perpendicular, would give a sectional area of 800 yards—that is, the expense (in estimate) would be the same as that of tunneling. But Mr. Vignoles observed that, in addition, the future maintenance of the tunnel should be taken into consideration, as well as whether the material from the cutting could be disposed of with advantage; the nature of the soil, and a variety of other circumstances which he stated, all of which would influence the decision. In soft rock, which would work with facility, and yet stand nearly perpendicular, the depth might be very much greater than 55 ft. before tunneling would be cheaper. In such cases, a depth of 80 ft. and upwards had been resorted to. In chalk, the proper slope to be given, which was very variable, would greatly alter any elements of calculation; while, on the other hand, in forming tunnels through chalk, experience had shown that water was the great enemy, and had entailed enormous expenses. The Professor went into a great many other points for comparing excavations with tunneling, but they appeared too technical to be satisfactorily explained in a brief abstract such as this.

On Viaducts and Aqueducts.

Mr. Vignoles next proceeded to the consideration of viaducts and aqueducts, into which, he observed, a totally different set of conditions enter, the cost varying from 20*l.* per lineal yard to the price for which no rule could possibly be laid down. Viaducts such as that of which the London and Greenwich railway wholly consists, may, probably, be executed for 20*l.* to 30*l.* per yard, including the foundations. Of course, the foundation entered materially into the calculation, and, where water had to be crossed, largely increased the expense. In some peculiar instances, a large river viaduct, or bridge, has cost as much as 200*l.* per lineal yard. The Professor instanced a viaduct he had built over the river Ribble, at Preston, for the North Union railway. The length was 300 yards, the height about 45 feet above the water, and the whole mass, including concrete foundations (where the rock was not attained), comprised about 25,000 cubic yards; coffer-dams were used for the piers, and for one abutment. The bridge consisted of five arches, each of 120 feet span, batiring on the face and spandrils from the parapet to the impost course—roadway about 27 feet wide; the total cost, including all contingencies, was £45,000, which is 150*l.* per yard forward, or 36*s.* per cubic yard on the whole solid contents; this might be considered a low

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span only, and with facilities for construction, can seldom be built for less than 20*s*. per cubic yard. Where no water, or expensive foundations, are to be encountered, and where the spans of the brick, or stone, arches do not exceed about 60 or 70 feet, 1*s*. per cubic foot on the solid contents of the viaducts may be put as a good covering price. Mr. Vignoles stated that, for such viaducts, about 60*l*. to 70*l*. per lineal yard might probably be taken as the average approximate cost, and the additional expense, from a considerable increase of height, does not become so very great, as it chiefly affects the piers only. The Professor then enlarged much on adopting timber arches, with piers of masonry, for viaducts of large span and great height, and produced a number of drawings of such bridges, some actually constructed, and some only proposed. The heights were from 70 to 130 ft., the *minimum* price being 35*l*., and the *maximum* 80*l*. per lineal yard. He further pointed out that high embankments should be avoided, and timber viaducts substituted, as a mere point of economy, even without taking into consideration the risk and danger of slipping in such great masses of earth. In an embankment only 40 ft. high, an occupation bridge for a farm would often cost nearly £1000; it was, therefore, only in crossing a very narrow valley or ravine, where no bridges under would be called for, and no masonry—except perhaps a culvert of the very smallest dimensions—that very high embankments should be made. Mr. Vignoles alluded to several such, varying from 70 to 90 ft. high, which he had made, and pointed out a terrible failure in one case, although in other instances success had followed. In passing through hilly countries and along mountain sides torn by ravines, the introduction of the timber-top viaduct, with stone piers, to overcome points of great but partial difficulty, was strongly recommended, especially as great additional height of viaduct could be given at small expense, and thus excavations on each side saved.

LECTURE X.—ON THE UPPER WORKS OF RAILWAYS.

This lecture was on the upper works of railways, which term, the Professor stated, was intended to comprehend every thing above the bed, or formation level, of the roadway—viz., the gravel, broken stone, or other road material, technically called the "ballasting;" the stone blocks, or wooden cross sleepers, laid thereon; the chairs and rails, and their fastenings, as attached to the stone, or timber, supports; and the boxing, or filling up, of the road material around these supports, when the railway is finally laid to the proper gauge, range, and level—the whole of the materials and adjustment forming the "upper works"—an expression borrowed from the German *oberwerke*. The depth from the road-bed to the level of the rails, of all these parts, as permanently laid together, is seldom less than two feet, when a good way is to be insured; the principle to be observed being to have the ballasting of such a material and nature that water will percolate freely through, as clean gravel, cinders, quarry rubbish, coarse sand, &c. The word "ballast" is a northern provincial term.

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Some of the first railways were introduced into the vicinity of Newcastle-upon-Tyne, Shields, and the neighboring coal shipping ports, and it being found necessary to have a bed, or layer, of some material to receive the railway track, the same not to be retentive of water; the gravel brought by the colliers from London as ballast, and accumulated in hills, or spoil-banks, near the sides of the harbors, was found to answer the purpose very well; the expression has since become common for whatever other material was similarly used for laying railroads. Mr. Vignoles observed that a great number of other technical words, now in common use when treating on railway works, were provincial terms, chiefly from the north of England. When the bottom of cuttings, or top of embankments, is of soft material, it was recommended to make a kind of pavement, or hard layer, on the forming level, below the ballast. On embankments, until they became well consolidated, this pavement would not, perhaps, be conveniently put in; still, means should be contrived to carry off the water quickly from the surface; and the Professor insisted much on the free introduction of blind, or French, drains, of broken stone, among, or under, the ballast, connected with the open side drains, which should never be omitted in cuttings; on embankments, these cross rubble drains should go free of the road-bed, with water channels down the slopes, of sods, or more substantially formed if needful.

The bed of the railway having been prepared on the above principles, next came the consideration of the railway itself. The substance first used for this trackway was wood, and afterwards a metal rail plated on the wood; after 200 years' trial of different systems—for so long was it since the first colliery wagon-ways were introduced—the Professor observed, we are just coming back to the original form and material as best adapted for the purposes of a railway, viz. timber laid longitudinally. When blocks of stone are used to support the chair and rail, weight seems to be sought for as desirable, and the general cubic contents of such blocks as are considered proper for a good way are about five cubic feet, viz., 27 inches wide, and a foot thick. When cross bearers of wood are the supports, each sleeper, as it is termed, contains about two cubic feet of timber, being about seven feet long, with a transverse section of 40 square inches, being full eight inches broad, and averaging five inches thick. The intervals at which the blocks, or sleepers, are placed, vary from three to five feet, according to the weight of the rail, or of the load. With these descriptions of support, it becomes generally necessary that a chair, or saddle, be attached thereto, to receive the rail, which is seldom fastened directly either on block or sleeper, without the intervention of this contrivance of a chair, unless when the rail is made wide and flat at the base. Such shaped rail is now much used in cross bearers of wood for temporary railways, by contractors, when executing works. Mr. Vignoles said this form of wrought-iron rail was first introduced, nearly twelve years since, on the St. Helen's railway, by some contractors, at his suggestion; and the same rails were lately in use by the same persons, and still good and serviceable after continued use. Of late it had been recommended by many en-

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ways in the direction of the way, and upon which the iron had a continuous bearing, instead of having it supported at intervals (either with or without chairs), as was the case when blocks, or cross timber bearings, were used. In describing the different modes of laying rails, the Professor observed that the heavy stone blocks being packed around, or boxed up, with ballast, kept the rails in place—that the cross sleeper having both rails attached thereto, the gauge, or breadth, was preserved; with the longitudinal system of bearings, the parallelism was retained by cross ties of wood, with tenons, and sometimes by rods of iron with screw-ends and nuts, and occasionally with both. It was necessary thus to provide for preserving the breadth of the railway, for, as the carriages and engines work along the rails with a wriggling motion, there is always a tendency, by the lateral action of the flanches of the wheels, to push the road out of gauge. Mr. Vignoles mentioned the two new lines added on the south side of the London and Greenwich railway, as the latest examples of longitudinal timber bearings; but he observed that, as the great point in this system was to insure that the rail be firmly attached to the wood, to prevent any vertical play, he considered a more effectual method might have been there used, so as to have the iron continually united to the timber, on a plan which he had tried with success, and to which he would presently advert. When iron was first introduced for railways, it was for a long time merely a plating of metal on the edge of the wood rail, on which plan, with iron bars of greater or less weight, many of the lines in America had been laid. Cast-iron being next introduced, the system of fastenings was necessarily changed, and the original longitudinal timbers abandoned for cross sleepers, or isolated stone blocks. The rails being cast in lengths of three or four feet, it was found expedient to prepare some contrivances to receive and fasten the ends together; and this was the saddle, or chair. Some of these iron rails were cast deeper in the middle, and, from their shape, got to be termed "fish-bellied," this form being probably adopted with the idea of obtaining uniform strength; though, for railway purposes, the position of this increased depth was the reverse of that given to bearers intended to resist quiescent weights. From the action of the moving weight, however, upon rails with so many joints, they soon got out of order. Wrought iron was then introduced, to get greater lengths; the first of these were rolled, at a considerable expense of useless ingenuity, into the same form as the fish-bellied cast-iron rails, the length of 15 to 18 feet being divided into five or six flat ellipses. On most of the lines where this description of rails was first laid, it has been found necessary to take them up, and replace them, as they were found to break at a short distance from the points of support. Mr. Vignoles stated that he had, from the first, decidedly set his face against this form of rail, and argued for and introduced rails with the same section throughout their length—since commonly styled *parallel rails*, as distinguished from the "fish-bellied rail," adding 10 lb. to the original weight of 35 lb. to the yard, by putting on a lower rib, or

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web, on the principle that such gave additional stiffness to all beams; this lower web was increased in size from time to time, until, in a special report to the London and Birmingham Railway Co., Mr. Vignoles recommended that the upper and lower webs, or buttons, should be made precisely alike, to allow the rail to be turned up or down, or in either direction. This form was, however, first actually laid down by him on the North Union railway, and its advantages in the above respects have already been appreciated and applied; these rails are about 65 lb. to the yard. The Birmingham Company decided, finally, on adopting this form, increasing the weight to 75 lb.; and, where chairs are used, it is now almost exclusively employed, the weight being sometimes increased to 78 or 80 lb. per yard. With the increase in the weight of the rail, the intervals between the supports also gradually increased from three to five feet, but with bad effect, as the expense of keeping a railway in order with the longer bearings (as the technical phrase is) was very much augmented; and, on the London and Birmingham railway, intermediate supports had since been introduced, where the original bearings were five feet. Mr. Vignoles stated it as his opinion, deduced from considerable experience and observation, that, where chairs and supports at intervals were used, he considered a 60 lb. rail, with a 3-feet bearing, better than a heavier rail with a longer bearing. Blocks, he observed, were, however, nearly exploded as supports; the cross sleepers and chairs were still preferred by many engineers; but it was certain that, the closer the supports—that is, the shorter the bearings—the less the cost of maintenance; and hence the inference, which experience every where confirmed, that the continuous supports were best of all. In respect of fastening the chair to the block, or sleeper, and the rail to the chair, it was now almost universally admitted and acted upon, that compressed wood was much preferable to iron spikes, bolts, or keys. Mr. Vignoles introduced a number of drawings, and described a variety of diagrams, illustrating the various shaped rails and chairs, and modes of fastening adopted, and drew comparisons as to the advantages and cost of each. In reference to what he had before stated of the disadvantageous method hitherto pursued in fastening rails with flat bases to continuous timber bearings, by spikes, or screws, the Professor said that such a mode seldom continued to hold the rail close down to the timber, and there ensued a certain quantity of vertical play of the rail on the wood, often accompanied with a good deal of rattling; and, in the end, the head of the bolt, or spike, was absolutely jerked off. Mr. Vignoles said that the only effective fastening was that used with Evans' patent rails, which had a slit, or groove, of a dove-tail shape, (in cross section,) rolled for the whole length of the rail in the bottom; bolts, with similar shaped heads to fit, were passed into this groove, and dropped, at the necessary intervals, through holes in the longitudinal timbers; the bolt terminated in a screw, and, a washer and nut being put on by means of a spanner, the nut drew down the rail closely to the timber. Mr. Vignoles stated that he had had a considerable length of railway thus laid, which had been done some time, and the rail had remained close

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down on the wood without any play, or getting at all loose. He concluded this lecture by stating that, in the next, he would endeavor to draw a comparison between the modern heavy rail, and chair and fastenings, as used with cross timbers laid at intervals, and the rail and fastening, as above described, to be laid on longitudinal timbers, and having a continuous bearing thereon.

(To be continued.)

Major General Pasley on the recent great Mining Operations near Dover.

[The following letter on this interesting subject appeared from Major General Pasley, Inspector General of Railways, in the Times of Monday.]

Sir—Having had frequent questions put to me in conversation respecting the great explosions near Dover, by which Round-down Cliff, an immense projecting mass of chalk in the proposed line of the South-Eastern Railway, was thrown down, I request your insertion of the following statement, in order to correct several inaccuracies in my own letter to you of the 23d of January last, which I wrote in haste, that it might appear in time to remove the impression which I found generally prevailed, that the whole operation was under my direction, but which I considered only a vague report, until I saw it quoted from an article in a paper, which quotation did not come to my knowledge until three days before the time appointed for the firing of those great mines.

To Mr. W. Cubitt, the engineer in chief of the South-Eastern railway, is justly due the merit of having conceived the idea of removing a mass of chalk rock, nearly 300 feet in length, but of still greater height, and averaging 70 feet in thickness, by simultaneous explosions of gunpowder, instead of employing laborers to scarp it away, which would probably have cost £8,000; and the merit of success also belongs to him, inasmuch as he took the most judicious measures to insure it; but, as he informed me that he never would have contradicted the reports which ascribed the entire superintendence of that great operation to me, and as he is not likely to publish anything on the subject, I am desirous not only of correcting the inaccuracies in my first letter to you, but also of supplying the omissions in the printed accounts, by noticing the useful labors of those who contributed to his success, which I have always made a point of doing, in every similar operation that has taken place under my own direction, and which I am sure that Mr. Cubitt would do if he wrote himself, as I know from the able resident and assistant engineers of the same railway, that, instead of assuming the whole merit of the works in which they have been employed under him, he has always been ready to acknowledge their services in the most liberal manner, both officially to the directors of the company, and personally in conversation, as I have witnessed myself.

The general impression that the mines near Dover were to be su-

Cubitt always intended to consult me, and that he would not, and did not, decide upon his plan of operation until after he had taken my opinion; and it was also known that he relied entirely upon my assistance for firing his mines simultaneously by the voltaic battery, of the use of which, as applied to mining, neither he nor his assistants had had any practical experience. Accordingly I went to Dover by his request, and introduced Lieutenant Hutchinson, of the Royal Engineers, who had been employed two summers under me in the operations against the wreck of the Royal George, and who happened, fortunately, to be on duty at that place at the time; so that I recommended him as the most proper person to superintend the firing of the proposed mines by the voltaic battery, provided that the permission of the Master-General of the Ordnance could be obtained to enable him to undertake this service, which was readily granted, on application being made to Sir George Murray by the railway company. Accompanied by this officer, I examined the drawings of Round-down Cliff, that had been prepared under the superintendence of Mr. John Wright, the resident engineer of this portion of the railway, to whom Mr. Cubitt referred me on the 10th of November last, and went with him into a drift, or small gallery, cut entirely through the cliff, and about 248 feet in length, which had originally been intended for the commencement of a tunnel through which the railway was to pass; a design that was abandoned afterwards on discovering that this part of the cliff was likely to give way sooner or later, and the plan of removing it by gunpowder was adopted in consequence. Shafts about 17 feet deep had been sunk from this gallery, and branches driven from the bottom of them further into the chalk, in order to obtain greater lines of least resistance, on the level of what would have been the bottom of the proposed tunnel, and agreeing with the position of the rails. Mr. Cubitt had previously told me, *that his rule for estimating the quantity of gunpowder for explosions in chalk was, to use half an ounce for each foot of the cubed line of least resistance.* As he talked of having charges of from 5000 to 6000 or 7000 lbs., I could not but be surprised at this unusual mode of estimating such very large charges by halves of ounces; but, on going to the spot, Mr. Wright explained the mystery by informing me that he had, by Mr. Cubitt's direction, fired four experimental mines in the course of the year, in which, having had no previous personal experience, he adopted the rule laid down by Major General Sir John Burgoyne, formerly of the Royal Engineers, and now President of the Board of Public Works in Ireland, for blasting in hard rock, which, as the line of least resistance in rock seldom exceeds a few feet, it was more convenient to determine in parts of an ounce than in pounds; and he also adopted Sir John Burgoyne's recommendation in his printed paper on blasting, by firing those mines with Bickford's fuses, which is an excellent expedient for blasts in rock, and inferior only to the voltaic battery, but such as I never would have used for mining. For example, Mr. Wright's first experimental mine, fired on the 5th of March, 1842, had a line of least resistance of 25 feet, was loaded with

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500 lbs. of powder, had a tamping of 50 feet, and was fired with 100 feet of Bickford's fuses, in two lengths. His three other mines, the largest of which had a charge of 1100 lbs., were each fired by 50 feet of Bickford's fuse. It is difficult to conceive anything more tantalising than these arrangements must have been, for I calculated that 100 feet of Bickford's fuse would burn nearly an hour, and that 50 feet of the same would burn nearly half an hour, before the explosion took place. Nothing can be more teasing than such suspense. Our practice in the Royal Engineers, before we began to use the voltaic battery, was very different, as we never allowed a greater interval between the lighting of the portfire, or fuse, and the ignition of the charge, than from one to two minutes, being just enough to allow time for the officer, or non-commissioned officer, who fired the mine, to retire to a distance sufficient for his personal safety. In all his experimental mines, which were fired singly, and independent of each other, Mr. Wright found that the rule deduced by Sir John Burgoyne with great care and skill from numerous experiments tried by his direction, in order to ascertain the proper charges for blasts in hard rocks, which had heretofore been left to the discretion of the miners, or quarrymen, and which, in practice, seldom exceed a few ounces, were equally appropriate for mining in solid chalk; in which the charges, calculated according to the above rule, produced moderate demolition, without throwing the fragments to a distance—an object always desirable, except in military mines, having not merely demolition, but destruction, in view.

After having had this matter explained, I again inspected the plans and sections of Round-down Cliff, and, considering the length of the gallery and the proposed lines of least resistance, two of which were to be about 56 feet, I was of opinion, from my own repeated experience in conjunct mines, which had not as yet been attempted by the engineers of the South-Eastern railway, that two mines only, with charges calculated to effect moderate demolition, could not possibly throw down the whole of the cliff. I therefore approved of three charges, to be placed at equal distances from each other, but the two extreme charges to be nearer to the ends of the gallery than to the intermediate charge in the centre of it; and as I thought that Sir John Burgoyne's formula must be calculated rather for very moderate, than for moderate, demolition, I was of opinion that the distances between the three charges should be somewhat less than two-lined intervals, which our own experiments on conjunct mines had established as the most proper for moderate demolition. In case of using three charges, Mr. Wright informed me that, whilst the line of least resistance of each of the two extreme mines would be 56 feet, that of an intermediate mine between these two would be about 62 feet, which lines required two charges of about 5,500 lbs., and one of 7,500 lbs., if calculated according to the above formula, without reference to their distances apart. This last point had not yet come under the consideration of the engineers of the South-Eastern Railway, who had only fired single and independent mines, as was before observed.

On giving my opinion first to Mr. Wright, and to Mr. Hodges, his

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assistant, and afterwards to Mr. Cubitt, the latter objected, and, as I admitted, on good grounds, to the extreme mines being moved nearer to the ends of the gallery, although this arrangement had been adopted by me with perfect success in all my conjunct mines, because he apprehended that this would cause the fragments from those two mines to be thrown out laterally on each side of the Round-down Cliff, in the direction of the gallery, prolonged so as to obstruct the proposed line of railway, more than if the whole were projected forward towards the sea. At the time when this conference took place, I did not know how many mines were prepared, as I had only gone down one shaft, and into one chamber, to examine, but did not walk through the whole of the gallery, so that the impression upon my mind was that three chambers were then in readiness for the explosion, which was confirmed by my afterwards hearing that three charges corresponding with the lines of resistance then mentioned to me, had actually been adopted; and, therefore, when I wrote to you on the 23d of January, it was natural for me to believe, not only that every arrangement had then been previously fixed by Mr. Cubitt, subject to my approval, but that all the three chambers were actually ready for receiving the gunpowder, and only waited for the voltaic apparatus, which had all to be made, as I recommended, in preference to borrowing.

I have since been informed by Lieutenant Hutchinson, that I was so far mistaken, that only two chambers were prepared at that time, so that the third shaft, with the branch and chamber leading from it, were excavated subsequently to my visit to Dover; and also that the position of one of the first two chambers was altered after the same period. Eventually the three chambers were placed at only 70 feet apart, thus dividing the length of the gallery into four equal parts; but the line of least resistance of the central chamber, on placing them all in the same allinement, proved to be 72 feet, which would have required a charge of nearly 11,700 lbs., according to Sir J. Burgoyne's formula; and yet the original quantity of powder calculated for 62 feet was not altered. These arrangements were thus definitively made, not before, but after, my visit to Dover, at the suggestion of Lieut. Hutchinson, after he (by permission of Sir G. Murray) had been placed in charge of the proposed mines; and were very judicious, because the chambers, being only 70 feet apart, were at much less than two lined intervals, even in reference to the shortest of the lines of least resistance (56 feet) above mentioned; and, in this case, if the central charge had been estimated according to the same formula as the others, violent demolition would have been produced, which was not desirable. In short, the same rule invariably adopted by us in the royal engineer department, in respect to conjunct mines, was here followed—namely, to diminish the regular charges, which are known to be capable of effecting moderate demolition, whenever they are placed at much less than two-lined intervals apart. Though this term is very generally understood, yet, perhaps, it may not be superfluous here to explain, that, in speaking of conjunct mines, the term "two-lined intervals" implies that the central distance between

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adjacent charges is twice the line of least resistance of each, the latter being the distance from the charge to the nearest surface of the rock, or mass, that is to be removed by the explosion.

The whole of the arrangements for firing these great charges by the voltaic battery, were made by Lieutenant Hutchinson, assisted by Lance Corporal John Rae and private Thomas Smith, of the Royal Sappers and Miners, and by two naval pensioners, John Leary, a blacksmith, capable also of working in tin or copper, and William Gordon, a rigger; all of whom had been employed under the same officer at Spithead, and who, in their several capacities, understood thoroughly every thing relating to the preparation of charges, and to the mode of firing them by the voltaic battery. Leary, who is an excellent workman, and who distinguished himself, some years ago, whilst under the command of Captain Dickenson of the Royal Navy, by converting ships' tanks into a diving-bell, by means of which that enterprising and intelligent officer recovered the treasure sunk in the Thetis frigate on the coast of Brazil, was employed, on his arrival at Dover, in making voltaic batteries for the proposed explosions, nine in number, each consisting of six cells of Professor Daniell's constant battery, such as had been used by me in all my mining operations; and he also put together the wires for three conducting apparatus, each 1000 feet in length, and, consequently, composed of 3000 feet of copper wire. Each apparatus consisted of a pair of wires attached to a strong rope, and secured and insulated by Pensioner Gordon in the same substantial manner that had been adopted by us at Spithead; for, though there was little necessity for guarding against the action of water, yet the letting it down and dragging it up the high chalk cliffs, exposed this apparatus to a good deal of wear and tear; and it might also have been injured by the hob-nailed shoes of railway laborers, to which it was continually exposed, as I observed particularly on the day it was used, when every person that came near it trod upon it, and which, had it not been thus protected, might have destroyed the connexion, and prevented the explosion, of which I have known instances in the course of our former experiments. As soon as the batteries and conducting apparatus were complete, Lt. Hutchinson tried experiments to ascertain whether he could fire all the three charges simultaneously by one powerful battery, *as had been done by Dr. Hare, of Philadelphia, who first applied voltaic electricity to practical purposes, by using it for blasts in rocks, to obtain stone for building, in* 1831; as minutely described in Silliman's American Journal of Science, vol. xxvi, page 352, and also briefly noticed in the transactions of the British Association for the Advancement of Science, held in Bristol in 1836. From his own experiments, tried with this object, Lieut. Hutchinson drew the same inference that I had done about three years before—namely, that one cannot depend upon more than two charges exploding simultaneously, for though, by a battery of extraordinary power, he succeeded in firing twelve small experimental charges at the distance proposed for the great mines under his direction, yet there was a perceptible interval of time between the reports, which resembled a volley of musketry rather

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four subaqueous charges simultaneously against the Royal George —namely, to have a separate voltaic battery for every charge, and a person at each, with one conducting wire fixed to a pole of the battery, and the other in his hand ready to complete the circuit, according to the time marked by the chief, who was to give the words—*one —two—three*—with an interval of about one second between each, and then the word *fire*, which was to be the signal for completing the circuit; and by this mode I expected that the explosions would all take place simultaneously, on the principle of marking time in music. The powder in each of the three chambers prepared for the several mines at Dover, was contained in bags, placed in a large box, the former expedient having first been adopted in the practice of the Royal Engineers at Chatham; but we never used box and bags also, which I considered superfluous. As these boxes formed what may be called double cubes, Lieutenant Hutchinson very judiciously had a couple of short branches forking out from the lower extremity of each conducting apparatus, into two central points of the oblong charge. Very short and fine pieces of platina were placed, according to custom, near the closed ends of strong tin tubes fixed to the outside, and leading into the centre, of the powder boxes, in which tubes bursting charges of fine powder were introduced, surrounding the platina wires, on the same principle that had been used at Spithead, but without those extreme precautions that had been found necessary to resist the great pressure of water to which our charges there were subject.

In the course of Lieut. Hutchinson's experiments, an unforeseen difficulty occurred, owing to Daniell's batteries, which had been very promising, losing their power after the first frosts set in. This difficulty had never embarrassed us before, because, in our experiments at Chatham, we always took the battery out of a warm room, and it required a longer time to impair its power than our experiments there ever occupied; and at Spithead, where Lieut. Hutchinson first used the battery, it was generally kept in the cabin of one of our lighters; besides which, the work was only carried on during the summer months. He was therefore obliged to have a small wooden shed built for his batteries at Dover, and to keep fires lighted whilst using them, by which means he got rid of the difficulty.

I have since been informed that, in experiments tried at Calcutta, a very energetic battery lost half its power when the temperature fell from 120 to 60 degrees of Fahrenheit. When this difficulty occurred, a prejudice was naturally excited against Daniell's battery, and four very powerful plate batteries were ordered at Dover in consequence, which were made by an intelligent tradesman of that town. The trough of each of these contained 20 cells, according to Dr. Wollaston's construction, with zinc and copper plates, measuring 7 by 10 inches, the latter of which were only let down into the trough when the battery was about to be used; and these plate batteries were combined with the batteries made by Pensioner Leary as before men-

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tioned, so that one very powerful battery, consisting of 40 plates of the common system, and of 18 cells of Daniell's constant battery, was to be used for each of the three charges. But here I must remark upon a great inaccuracy in my letter to you of the 23d of January last, in which I stated that the length of conducting wires about to be used at Dover was far greater than had ever been used by me either at Chatham, or at Spithead, instead of which the contrary was the fact; for, on referring back to the journal of our experiments at Chatham, I find that we fired an experimental charge on the 7th of July, 1839, at the distance of 1,950 feet, by 14 cells only of Daniell's constant battery, as recorded in the United Service Magazine for January, 1840; being more than twice the distance at which the great mines at Dover were afterwards fired by batteries of three times that magnitude, and at a temperature which could not have been less than that of our experiment. I said twice the distance, because the conducting apparatus for the charges at Round-down Cliff, originally each 1000 feet long, were afterwards reduced to less than 900, their former length being unnecessarily great. I thought it right to rectify this error, lest a prejudice should be excited against Daniell's constant battery by its supposed inferiority, which led to the employment of plate batteries at Dover, in addition to those of his pattern, which were first made. At the same time, I am now of opinion that the plate battery is the most convenient of the two for firing gunpowder; and the simplest that I have seen is that which is now being used by Mr. R. Davidson, of Aberdeen, in his interesting exhibition of electro-magnetic power at the Egyptian Hall, Piccadilly, which I visited lately in company with Dr. Faraday and Mr. Brand. This battery, which contains 20 cells, differs from Dr. Wollaston's in using amalgamated zinc, and in substituting plates of iron instead of copper, all the plates measuring 8 by 11 inches, and the action being produced by diluted sulphuric acid, upon the purity of which, Mr. Davidson says, the efficiency of his battery chiefly depends. On inquiring who first adopted iron plates instead of copper, Mr. Davidson assured me that he had used the former metal himself for about twenty years, but that the merit of this arrangement was disputed by Mr. Sturgeon and Mr. J. Martyn Roberts, with whom he himself had not thought proper to contest it. Dr. Faraday observed, that articles published in any public or scientific journal afforded the only genuine grounds for deciding upon priority of inventions; for the same idea might occur to several persons, and the individual who worked in private must give way to those who published. On this plea, I advise those who ascribe the merit of applying the voltaic battery to the purposes of blasting in earth, or rock, or the peculiar construction and management of the first plate battery, well calculated for this purpose, to any of our own countrymen, to refer to the documents before quoted, and they will find that they are doing an injustice to Dr. Hare, of Philadelphia. But it must not be forgotten, that Mr. William Snow Harris, of Plymouth, was prior even to Dr. Hare, having fired gunpowder by electricity in March, 1823, which he effected, to the astonishment of numerous spectators, by a common electrical machine, from the cabin

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the water, through which his conducting apparatus passed. But the electrical machine, though perfectly efficient, never would have superseded the common modes of firing mines, as the voltaic battery has done, because the former not only requires a much more delicate manipulation than could be expected either from civil or military miners, and would be more easily broken, or deranged; but it also requires artificial heat at all times, even in summer; whereas the voltaic battery can always dispense with this very inconvenient arrangement, even in the depth of winter, except in the case of very long exposure to a low temperature, which can seldom occur.

To return from this digression to the mines near Dover. By the 26th of January, the day appointed for the explosion, all the great charges had been placed in their respective chambers, with the two small bursting charges in the centre of each, whilst the conducting apparatus were led thence, two out of the east, and one out of the west, end of the gallery, to the summit of the cliff, about 300 yards beyond the edge of which they were united with their respective batteries. These were placed alongside of one another in the shed before mentioned, in which powerful charcoal fires were kept burning, one near each battery. The mines had been tamped by filling up the branches and shafts, and ten feet of gallery on each side of the shafts with rammed chalk, but leaving a vacant space of several cubic feet at each chamber, which had not usually been done by me, as my first experiment left me in doubt whether any advantage was obtained from this arrangement. Before the hour appointed for the explosion, the three voltaic batteries, each consisting, as before mentioned, of 40 sets of Wollaston plates and 18 of Daniell's, had been got ready by Lieut. Hutchinson, assisted by Lance Corporal Rae and Private Smith, who had been specially employed under him all last summer in preparing and firing the numerous subaqueous explosions at Spithead. Mr. Wright and Mr. Hodges, who had been present at, and assisted Lieut. Hutchinson in, his preliminary experiments, were now each stationed at one battery in readiness, whilst that officer himself took post at the third, to give the word of command.

The position of the spectators, and the signals for firing, &c., have been so well described by our own reporter, as well as by Sir John Herschell, in the Athenæum, and in other papers of the day, that I shall only remark that considerable anxiety was caused by the unexpectedly long intervals that elapsed between the first and second signals, which led the spectators to apprehend that something had gone wrong, or been forgotten. At last, the second signal was made, and the third signal for firing followed at the appointed interval. At this moment, the lower part of the cliff was seen to swell, or bulge, out, immediately after which the top of it descended gradually, whilst the bottom also was put in motion, and flowed slowly towards, and into, the sea, spreading out, at the same time, to more than its original width; and as it approached and filled up part of the water, a black margin was observed issuing from the extreme outline of this extra-

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ordinary stream of white chalk, which was at the time apparently in a fluid state. No smoke was perceived anywhere, unless the dark border, of which no trace remained afterwards, was such. I neither heard a report, nor felt a shock, myself, nor had I anticipated any, from the small quantities of powder used—that is, comparatively small, in reference to the depth at which the charges were buried; but the former was perceptible to many of the spectators of more acute hearing, and the latter was felt also, and described as a slight tremulous motion of the earth, by some of them. It was particularly noticed by those who were seated on the ground near me, at a high point of the cliff to the westward, which commanded a flanking view of Round-down. I would have preferred standing much nearer, and indeed a person at the distance of fifty yards from the edge of Round-down Cliff itself would have been perfectly safe, but it was impossible to have a good view except from a distance. Lieut. Hutchinson and his assistants lost the sight, and, as they felt no shock and heard no explosion, they were not without some apprehension that their mines had failed, until they rushed out of the battery-house, and heard the repeated cheers of the delighted spectators, amongst whom the hardy railway laborers, who are chiefly men of Kent, were not the least vociferous. The cause of the delay between the first and second signals was now explained to me by Lieut. Hutchinson. One of the three batteries, when tested by the voltameter, proved inactive, and, therefore, there was reason to fear that the conducting apparatus of one charge might have been deranged. But, on a closer investigation, it was found that a zinc rod in one of Daniell's batteries had broken by some accident; at which I was less surprised, because I had previously remarked on the very bad quality of the zinc, supplied from London, of which these rods had been made. On discovering this defect, that battery, consisting of six cells, was set aside, and the connexion was made by the remaining twelve, combined, as before stated, with forty sets of Wollaston plates—a power of battery even then far exceeding what was absolutely necessary; but it is best, on great occasions, to employ a superfluity of power, as I myself have always done.

Soon after the sort of volcanic movement caused by the explosion had come to an end, we observed from the top a great number of spectators, who had stood below at a respectful distance from the foot of the cliff, but who now ran and spread themselves over the masses of chalk that had been moved towards the sea, and covered a large space of ground. These persons appeared like pigmies from the high and distant point whence we viewed them; and the moving stream of chalk which flowed towards the sea, when seen from the same point, had previously appeared as if it had been crumbled into white powder, for no part of it seemed larger than the usual size of beach shingle, and the inequalities on its surface were imperceptible; but, on descending the cliff and examining the *debris*, we were surprised to find that they consisted of large irregular fragments of all sizes, some of which must have weighed more than a ton, and which were

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heaped up, or packed, on some places, to the height of about thirty feet, but more spread out in others.

Here and there we found fragments of earth and grass that had originally covered the top of the cliff, lying upon those rugged masses of chalk below, which, when seen from above, had appeared like dark brown spots on a white ground. As it was extremely troublesome and fatiguing to walk over the *debris*, for the smaller lumps of chalk rolled under the foot, and the larger ones could not be ascended or passed without an effort, several persons went down to the beach in order to go entirely round them, it being then low water, in which they afforded some merriment by sinking up to their middle, or falling down in crossing some little quagmires of very fine chalk and mud, with small temporary streams flowing through them from the bottom of those great masses, which had prevented the whole of the water of which they took the place from escaping quickly as the tide fell. A flagstaff had been placed at the summit of the cliff before the explosion, which was found prostrate, but uninjured, at some distance from the bottom of it, and was set up again, with a flag of the same color, on the spot, by the railway laborers. I observed a considerable portion of the voltaic conducting apparatus, which had also been thrown down; when afterwards collected and opened, for very little of it was lost, the copper wires were found to be much injured by the kinks occasioned in its fall, but externally it had appeared perfect. That the ruins of the chalk cliff thrown down by this great explosion should have covered fifteen acres of ground, may appear surprising, or even incredible, to many, as, from recollection, it did to me, until I was assured that an accurate survey of it had been made by Mr. Hodges, of which such was the result. The new face of the cliff produced by these great mines was nearly parallel to the original slope, but of a more regular form, being nearly a plane surface, except at the bottom, where a proportion of small chalk rubbish, brought down by the explosion, is piled, at a greater slope, against that which still remains solid.

Gratified, as they could not fail to be, by the splendid results of an operation that probably did not save less than £7,000, the Chairman and Directors of the South-Eastern Railway Company addressed a letter of thanks to the Master-General and Board of Ordnance, on the 16th of February, "for having allowed Lieut. Hutchinson, of the Royal Engineers, assisted by Lance Corporal Rae and Private Smith, to make the arrangements for, and superintend the firing of, the great mines at Dover, on the 26th of January, by which the entire removal of Round-down Cliff was completely effected;" and further observing, "that the important operation referred to having been accomplished by the voltaic battery, with a degree of skill as gratifying to the Directors of the Company, as creditable to the talents of Lieut. Hutchinson and those acting under his directions, they solicited the permission of the Master-General and Board, that Lieut. Hutchinson might be allowed to receive from the Company a piece of plate, which the Directors were desirous of presenting him with, in token of the

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high estimation in which his valuable services on the memorable occasion referred to, were held by them."

This proposition having been acceded to by the Master-General and Board, "as a special case," for it is contrary to etiquette that the services rendered by an officer of the army should be noticed by any mark of approbation, except by his own superiors, if performed as a part of his military duty, or by their permission, if otherwise,—as soon as this was communicated to them through Mr. Byham, the sum of fifty guineas was expended by the Chairman and Directors of the South-Eastern Railway Company in this testimonial of their gratitude to Lieut. Hutchinson.

Finding the immense benefit of this great explosion, Mr. Wright and Mr. Hodges, by the approbation of their chief, have since fired several other mines with equal success, in the same range of chalk cliffs, by the voltaic battery, of which they acquired a thorough knowledge, as well as of the general principle by which conjunct mines ought to be regulated, whilst under Lieut. Hutchinson—viz., two mines of 750 lbs. each on the 10th, and two of 900 lbs. each on the 14th, of February; after which, on the 2d of March, they fired eight conjunct mines, all in the same line, in which they expended 6,440 lbs. of gunpowder, along a range of cliff of such very irregular outline that they varied their charges from 200 lbs. to 2000 lbs. Mr. Hodges has contrived a simple and ingenious apparatus for completing the circuit of several voltaic batteries at the same moment, by one operator; and they propose to fire more than 12,000 lbs. of powder, distributed amongst fifteen or sixteen conjunct mines, in order to remove another portion of the same cliff, on the 18th instant. In short, these gentlemen, who had no knowledge of this art a year ago, have profited so well by their opportunities, that I consider them capable of planning and executing any mining operation, however extensive, with skill and success.

In respect to conjunct mines calculated for a scale of moderate demolition, I shall here remark, that it is not absolutely necessary that they should all explode at the same moment of time, (which is difficult even by the voltaic battery, but, by all the former methods of firing gunpowder, absolutely impossible, though the contrary has been asserted by writers copying from the old French authors on military mining.) For example, in the course of our experiments at Chatham, before we knew the use of the voltaic battery, we first demolished a brick wall, about four feet thick, by blasts fired successively by a very small powder hose leading along the back of the wall, and connected with each charge, one end only of which hose was ignited. In like manner, Lieutenant (now Captain) James, of the Royal Engineers, acting under my direction, demolished 466 feet in length of the brick revetments, or retaining walls, of an entire front of the old fort of Sheerness, with the exception of one of its flanks, but including its ravelin, with such complete success, on the 14th of July, 1827, that the brickwork was, as it were, just turned over nearly on the same spot, but crumbling into pieces as it fell, without any of the fragments being thrown to a distance, although no two of the explosions were

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simultaneous. In this operation, 15 charges, generally of 84 lbs., but some of 90 lbs., in barrels, were used against the demibastion and curtains, whilst 23 charges of 25 lbs. each, placed in bags, were used against the ravelin. The former were grouped by twos or threes as conjunct mines; the latter were all fired one after another, at intervals of several seconds of time, by igniting one end of a longitudinal hose laid along the top of the wall, and communicating with separate vertical hoses leading down into the several charges. But though simultaneous explosion is thus evidently unnecessary in conjunct mines, having their charges calculated to effect moderate demolition —yet, in the case of violent demolition, absolute precision is indispensable, otherwise the explosion of the first charge may derange the others, and either diminish the general effect of the whole, or even cause some of them to fail altogether, of which I have known instances.

The great explosion which took place at Dover on the 26th of January last, is certainly the triumph of the art of mining in this country, but the British military engineers, by whom undoubtedly it has been brought to perfection, were not so fortunate in their first attempts as the able civil engineers of the South-Eastern Railway. Owing to the inefficient state of the Royal Engineer Department at the commencement of the present century, which was not improved until towards the close of the Peninsular war, the officers had no opportunities of acquiring practical knowledge of this important art. Hence in Sir John Moore's retreat all the mines of demolition made for the destruction of the bridges in our rear failed, excepting one, in which Lieutenant Davy, a most promising young officer, blew himself up along with the bridge that he destroyed; and I myself was one of the unsuccessful operators in that campaign, in an undertaking in which no non-commissioned officer, and very few privates of the corps would now fail. At the siege of Badajoz, Captain Stanway, a most gallant and intelligent engineer officer, succeeded in placing a charge to blow up a dam that retained an inundation, which was a great impediment to the besiegers, but the explosion failed, from the mode of securing charges against the pressure of water not being then understood; and in the attack of Burgos, the work of the British miners was obliged to be suspended from time to time, for want of air, because the simple method of ventilating military mines was not known. Towards the close of the Peninsular war, however, the distinguished engineer officers employed in it had acquired more experience, and none of their mines of demolition against bridges, &c., failed as at first.

In India, where the same defects prevailed, perhaps to a still greater extent, the first mining operations after the commencement of the present century were not merely unsuccessful, but calamitous, for at the siege of Cumoona, an insignificant little mud fort, in 1807, the company's engineer officer, whilst preparing mines to throw down the enemy's counterscarp, was himself blown up in his own gallery, by the native miners opposed to him, and our troops were afterwards repulsed with great slaughter in an attempt to storm the place, which,

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however, was afterwards evacuated in the night. About two years before, in the first siege of Bhurtpore by Lord Lake, the repeated assaults ordered by that gallant general had been repulsed, chiefly by explosions of gunpowder prepared in the ditch. More recently, the East India Company's Engineers have everywhere distinguished themselves by their superior skill in mining, especially at the second siege of Bhurtpore, in 1826, though the native miners there had lost nothing of their former energy, for they actually penetrated into one of our galleries, where a combat took place, in which a captain of the Engineers was wounded. Their efforts were, however, unavailing, for the Company's Engineers opened the way for our storming parties into that supposed invincible fortress by two great mines, one of which not only effected a broad and practicable breach, like the other, but leveled in the dust a large circular bastion, on which 300 or 400 of the enemy's bravest troops were posted, who were all destroyed by the explosion. I need scarcely mention that the East India Company's Engineers performed the same important service in Lord Keane's attack of Ghunzee in 1829. Failures on either of those occasions, such as had previously occurred after the beginning of the present century, would have shaken our Indian empire to its centre. In Europe and America, where the Royal Engineers only are employed, mining has not been required in any of our military operations subsequent to the close of the Peninsular war; so that they have not had the same opportunities of establishing their character for skill in mining, which their friends and contemporaries of the same branch of service in India have enjoyed.

If my first letter, which appeared in your columns of the 24th January last, had not been full of inaccuracies, I would not have troubled you either with the above account of the great mines at Dover, or with the observations on the progress of the art of mining in the British service, into which I was led in the course of my narrative, for the length of which I beg to apologize, and am, Sir,

Your most obedient servant,

C. W. Pasley, *Major-General.*

Civ. Eng. & Arch. Journ.

Architecture.

Tesselated Pavements—Ancient and Modern.

[A work has been recently published, at a great expense, under the direction of Mr. Blashfield, who is connected with the old established firm of Messrs. Wyatt, Parker & Co., the cement manufacturers, for the purpose of exhibiting to the profession what truly beautiful patterns may be adopted in tesselated and mosaic pavements, by the aid of the small porcelain squares recently introduced by Mr. Blashfield for that purpose. The work consists of ten elaborate designs by Mr. Owen Jones, the author of the "Alhambra," splendidly printed in colours. These designs cannot fail in directing the public taste to

this admirable description of ornament, for the floors of halls, saloons, conservatories, baths, &c.—we may also add the aisles of churches; for to our taste, it is far preferable to the dingy encaustic tiles. The following essay on the materials and structure of tesselated pavements is by Mr. F. O. Ward, who has devoted considerable research in collecting the information.]

The object of the following notice is to call public attention to a new material for tesselated pavements, and to an improved method of constructing the same, by the adoption of which this ancient and esteemed mode of decoration may be re-introduced, at a moderate cost, for the embellishment of our modern buildings. The improvements in question will, it is confidently believed, enable the modern architect to execute mosaic floorings, equal in point of extent and elaborateness to the most celebrated of the remains that have descended to us from antiquity, and very far superior to these in brilliancy and variety of colouring, in the accurate co-adaptation of the pieces, and in the uniform durability of the surface.

In order to arrive at a just conclusion on this subject, it will be necessary in the first place to bestow some attention on the materials and structure of the old Roman tesselated pavements, as described by Vitruvius, and still to be traced in the remains existing in various parts of the country, and in the specimens preserved at the British Museum.

The materials of the best and costliest pavements at Rome (such, for example, as those still remaining in the baths of Caracalla,) are colored marbles of various kinds, differing considerably from each other in hardness and durability. The inferior pavements, found scattered through Britain, France, and other parts of Europe, and along the Northern coast of Africa, are usually made of such coloured stones as the neighborhood happened to supply, with the exception only of the red tesseræ, which are almost invariably of burnt clay. Thus, in the celebrated Roman pavement which was discovered in 1793, at Woodchester, in Gloucestershire, the gray tesseræ are of blue lyas, found in the vale of Gloucester,—the ash-coloured tesseræ of a similar kind of stone, often found in the same masses with the former,—the dark brown of a gritty stone, met with near Bristol, and in the forest of Dean,—the light brown of a hard calcareous stone, occurring at Lypiat (two miles from the site of the pavement)—and the red tesseræ, as usual, of fine brick. These materials differ from each other in point of hardness even more than the colored marbles of the costlier pavements at Rome; and it is evident that a surface composed of such heterogeneous materials must wear unequally at different parts, and ultimately fall into hollows wherever colors produced by the softer kinds of stone are employed.

If this remark should be met by a reference to remains of ancient pavements, discovered in this country after a lapse of sixteen centuries from their first construction, and still retaining a level, unworn surface, it is obvious to reply, that the mere length of their duration gives no force to the objection, seeing that, during by far the greater portion

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residences of Roman provincial governors, and were, therefore, doubtless, subject to very inconsiderable traffic. The entrance hall of a modern club-house would afford a much more trying test of durability; and it will hardly be disputed that a pavement composed of heterogeneous materials would in such a position be liable to wear unequally.

The next point to be observed with reference to the Roman tesseræ, is the want of uniformity in their size and shape, and the consequent irregularity of their junctures, especially in the more minute portions of the design. Whoever will take the trouble to examine the choicest specimens of old pavements at the British Museum, (as, for example, one presented by Mr. Lysons, which formed part of the Woodchester pavement referred to above,) will perceive that the tesseræ, instead of coming into contact by smoothly ground and equal sides, are in many places separated by broad and uneven lines of cement. In some parts the intervals are of such width that the cement, which in a good pavement would be scarcely seen, forms at least a fourth of the visible surface. It is scarcely necessary to point out the effect which this net-work of brown cement lines, running through the whole design, and mixing a muddy hue with every tint, must have in diminishing the purity of the colors, and in deadening the sharpness and brilliancy of their contrast. It is much as if a picture, when finished, should be crossed and re-crossed all over with lines of brown paint.

Proceeding from these remarks on the materials of the Roman pavements to consider the mode of their construction, we shall find that, while the effect produced was imperfect, the means employed for its production were costly and inadequate to the end proposed.

Vitruvius, in the first chapter of his seventh book of architecture, after describing the manner in which the foundation of the pavement should be formed, goes on to say, that on the topmost layer of cement the tesseræ are to be laid—care being taken to keep the surface flat and true with the level; that, in the next place, all unevennesses and projections are to be worked down by rubbing and polishing; and that, lastly, a layer of cement is to be spread over the whole and scraped off again (in order, it would seem, to fill up any cavities in the cement between the tesseræ, and to render the surface as smooth as possible all over.)*

We need not dwell at length on the time and trouble that it must have taken to set each tesseræ separately in the cement, and to try the surface with the level after every few pieces were laid. With respect to the subsequent operation of grinding down and polishing the surface of the work, it must have been in most cases, (and particularly where stones of a hard and gritty nature were employed) the most tedious and laborious part of the process. We shall pre-

* This is the general sense of the passage, according to the best commentators. The phraseology in the original is here very obscure, and has probably suffered from the carelessness of early transcribers.

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next proceed to describe—taking, however, in the first place, a rapid survey of the various experiments which preceded this invention, and of the successive improvements by which it has been gradually brought to perfection.

About forty years ago, a patent was obtained by Mr. C. Wyatt, for a mode of imitating tesselated pavements, by inlaying stone with colored cements. Floors thus constructed, however, were found liable to become uneven in use, in consequence of the unequal hardness of the materials; which defect prevented their general adoption. Terra cotta inlaid with colored cements has also been tried, and found liable to the same objection.

During the last ten years, cements colored with metallic oxides, have been used by Mr. Blashfield, to produce imitations of the ancient tesselated pavements; and, for work protected from the weather, the material appears to have answered tolerably well; but for out-door work, required to stand frost, it has been found necessary to employ Roman cement, the dark brown of which gives a dingy hue to all colors mixed with it. This, with some other practical difficulties, has interfered with the success of the plan.

Bitumen colored with metallic oxydes has also been tried by Mr. Blashfield, as a material for ornamental floorings. The groundwork of the pattern was first cast in any given color, and the interstices were afterwards filled up with bitumen of various other shades. But this method was even less successful than the former; the contraction and expansion of the bitumen soon rendered the surface uneven; the dust, trodden in, obscured the pattern; and the plan, besides being ineffectual, was expensive.

Three years ago, Mr. Blashfield succeeded in constructing an extensive and elaborate inlaid pavement, on the plan of the Venetian Pisé floors. It was made after designs furnished by H. S. Hope, Esq., at whose country-seat, Deepdine, in Surrey, it was laid down. It is still in good preservation.*

In the same year (1839) Mr. Singer, of Vauxhall, obtained a patent for a mode of forming tesseræ, by cutting, out of thin layers of clay, pieces of the required form, which are afterwards dried and baked in the usual way. His patent also included an improved method of uniting the tesseræ with cement, so as to form slabs of convenient size for paving. He has executed in this manner some very admirable mosaics, and his invention must be regarded as one of the most important steps towards the revival of the art in this country.

We now come to the discovery which led to the invention of the tesseræ particularly referred to throughout this treatise.

In 1840, Mr. Prosser, of Birmingham, discovered that if the material of porcelain (a mixture of flint and fine clay) be reduced to a dry powder, and in that state be subjected to strong pressure between steel dies, the powder is compressed into about a fourth of its bulk;

* A floor of a very similar kind was laid down at Mr Hope's mansion, in Duchess street, about sixty years since, and it is said to be still in excellent condition.

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much less porous, and much harder than the common porcelain, uncompressed.

This curious, and as it has since proved, very important discovery, was first applied to the manufacture of buttons, to supersede those of mother-of-pearl, bone, &c. The buttons thus stamped out of porcelain powder are capable of resisting any pressure to which they are subject in use, and are more durable, as well as cheaper, than buttons of the materials ordinarily used.

The applicability of this ingenious process to the manufacture of tesseræ for pavements, soon afterwards occurred to Mr. Blashfield; who made arrangements with Messrs. Minton & Co., (the manufacturers appointed to work Mr. Prosser's patent,) for a supply of small cubes made according to the new process; these he submitted to various trials and experiments, and having found them in every respect suitable for the purpose, he has recently, in conjunction with Messrs. Wyatt, Parker & Co., carried out the invention on an extensive scale. Tesseræ of various colors and forms—red, blue, yellow, white, black, brown; quadrilateral, triangular, rhomboidal, hexagonal, &c.—have been manufactured on this principle in large numbers; pavements of considerable extent have already been constructed with them; and they have been found to possess the following advantages:—

First, being formed in similar steel dies, they are of uniform size and shape, so that they can be fitted together accurately in the laying down of the most complicated designs. Secondly, being all composed of the same material, variously colored, they are all of precisely equal hardness, so that pavements made with them are not liable to fall into hollows in use. Lastly, owing to the effect of the intense pressure under which they are made, they are quite impervious to moisture, of flinty texture throughout, and, in a word, to all intents and purposes absolutely imperishable.

In these several respects, their superiority to the Roman tesseræ, (which, as we have seen, were shaped imperfectly by hand, and differed from each other in hardness,) must be manifest to the reader. Nor less conspicuous is the superiority of the modern process of uniting the tesseræ to form pavements.

For this purpose (instead of spreading the cement on the surface to be paved, and laboriously setting each single tesseræ in it, according to the directions of Vitruvius,) the pavement is first put together, face downward, on a smooth surface, so that the tesseræ find their level without any trouble to the workman; and as soon as a sufficient portion of the design is finished, it is backed with fine Roman cement, which is worked in to fill the crevices between the tesseræ; the pavement is thus formed into smooth flat slabs of convenient size (according to Mr. Singer's method) and these are laid down on a foundation properly prepared in the usual way.

One peculiar feature of this process is, that private persons, if so inclined, may set out their own pavements in the colored tesseræ,

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slabs. The mosaic work for the tops of tables, for illuminated monuments, &c., may be made in the same manner with a superior kind of tesseræ, glazed on the surface, and richly ornamented in gold and colors.

Pavements thus constructed are singularly beautiful. The outline of the design strikes clearly and sharply upon the eye, and the brilliant colors of the tesseræ are reflected from the level surface, uninterrupted by those broad, uneven lines of cement, which in the Roman pavements detract so much from the general effect. The truth of every line and angle in the figure, and the just proportion of all its parts, however complicated and various, impress the mind with an agreeable sense of order and precision. Such, indeed, is the exactness and facility of the workmanship in these pavements, that the oblique and intricate intersections of the Mauresque designs are as readily executed as the simple rectangular patterns of the Pompeiian style. Even the scrolls and twisted guilloches, the quaint emblematical device, and grotesque representations of horses, warriors, &c., found in the most elaborate of the Roman pavements, may be accurately imitated with the new stamped tesseræ.

The Roman designs, however, have little to recommend them to the modern artist, beyond their historical interest. Even the earliest of them, which are the best, were produced subsequently to the Roman invasion of Greece, when art was everywhere declining; and they abound with indications of the extravagant and licentious taste which grew up amidst the general corruption of Roman manners, occasioned by the rapid influx of foreign wealth, and foreign habits of luxurious excess.

When designs after the antique are required, the elements of them should rather be sought in the beautiful decorations of the Etruscan vases, and in the admirable remains of Greek art in general, during its best period—*i. e.* from about 400 to 200 B. C. or during the time of Phidias, Praxiteles, and their immediate successors. (Such are the models which have guided the composition of the magnificent tesselated pavement designed by Mr. Barry, and executed under his direction by Mr. Singer, for the hall of the New Reform Club; a pavement so beautiful and so generally admired, that it can hardly fail to give an impulse to the re-introduction of mosaic decoration hitherto so sparingly employed by modern architects.)

For Mauresque designs, the mosaic dados of the Alhambra may be advantageously consulted. They are executed in glazed earthen tiles, variously colored, shaped with considerable exactness, and joined with cement. They present many examples of ingenious arrangement and well contrasted coloring.

But, whichever of these various styles the architect may adopt, he will find that, for the realization of his conceptions, there is no material which presents so many advantages as the compressed porcelain tesseræ—whether on account of their uniform size and shape—the purity and brilliancy of their colors—or their extreme hardness, and unalterable durability.

Civ. Eng. & Arch. Jour.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On Public Cemeteries. By JOHN C. TRAUTWINE, *Collaborator on Architecture.*

The following extracts from an article on Public Cemeteries, will doubtless prove highly acceptable to many readers of the Journal. It is selected from an able treatise on the subject, written by Mr. J. C. Loudon, of London, Conductor of the Gardener's Magazine, the Architectural Magazine, and other periodicals and architectural works, which have acquired for him, in the United States, a well merited reputation as a gentleman of refined taste, and close observation.

We have begun in this country to give the Public Cemetery system a fair trial; and the entire success, and universal satisfaction which have hitherto attended the experiment, furnish every assurance that the system will eventually become general; while the consequent desire to obtain the most authentic information on the subject, must ensure a cordial reception to a paper like the following, emanating as it does from so high a source.

The extension of the system will be attended by many important advantages to the public. Not only will it remove from our cities a source of disease, much more noxious than is generally supposed, but it will exert a powerful influence in exciting and diffusing a taste for that delightful branch of ornamental agriculture, landscape gardening, which has hitherto remained comparatively unpracticed, and, indeed, almost unknown in this country. Landscape gardening, when conducted on scientific principles, constitutes one of the most agreeable and essential accessories to the beauty of rural architecture; and when our cemetery companies possess the advantage of spots so eminently calculated for its display, as Laurel Hill, Monument Cemetery, Mount Auburn, and others, a free application of its principles cannot fail to arrest the attention of every observer endowed with a spark of natural taste, and gradually lead to its more general subserviency to architectural purposes. Hence I do not hesitate to recommend the introduction of this paper under the head of "Architecture," in the Journal of the Institute.

The erection of monuments designed on architectural principles, contrasting as they necessarily will, with those common-place designs which impart to our grave-yards an air of funereal stereotyping, must likewise aid in improving the architectural taste of the visitors. Even the less observant will perceive that the most costly and profusely decorated monuments are not necessarily the most beautiful; many will thus be led to inquire what contributes the elements of beauty in architectural design? and this inquiry will by degrees extend itself to our public buildings, until the mass of our citizens shall at length derive from the contemplation of a structure erected in conformity with strict architectural principles, some degree of that refined gratification, which is now confined to a very few.

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The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

The circumstance of being employed by the Directors of a Cemetery Company at Cambridge, to form a plan for their guidance in arranging the ground, and in working and managing the cemetery afterwards, led us to study the principles on which all the arrangements connected with cemeteries are, or ought to be, founded, and the following pages contain the general results of our inquiries.

I. THE USES OF CEMETERIES.

As, to know the best mode of applying the principles of design to any particular object, it is necessary to know the purposes for which that object is intended, we shall commence by considering the *uses* for which cemeteries or burial-grounds are required.

The *main object* of a burial-ground is, the disposal of the remains of the dead in such manner as that their decomposition, and return to the earth from which they sprung, shall not prove injurious to the living; either by affecting their health, or shocking their feelings, opinions, or prejudices.

A *secondary object* is, or ought to be, the improvement of the moral sentiments and general taste of all classes, and more especially of the great masses of society.

With respect to the first and most important object, the decomposition of the dead, without the risk of injury to the living, there is, as we think, but one mode in which this can be effected, to which there can be no objection on the part of the living; and that is, interment in a wooden coffin in the free soil, in a grave 5 or 6 feet deep, rendered secure from being violated, in which no body has been deposited before, or is contemplated to be deposited thereafter.

Various circumstances, however, into which it is needless to inquire, have given rise to burying several bodies in the same grave in the free soil, and to modes of sepulture by which the decomposition of the body, or at least its union with the earth, is prevented; such as the use of leaden or iron coffins, and depositing them in vaults, catacombs, and other structures, in which they can never, humanly speaking, except in the case of some great change or convulsion, be mingled with the soil, or, in the beautiful language of Scripture, be returned to the dust from which they sprung. Though we are of opinion that the modes of burial which prevent the body from mixing with the soil, which, for the sake of distinction, we shall call the sepulchral modes, cannot, on account of the danger to the living, be continued much longer in a highly civilized country, yet, in considering the conditions requisite for a complete cemetery suited to the present time, the various modes of sepulchral burial at present in use must be kept in view. The expense of the sepulchral mode, however,

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part of burial-grounds always was, and is, necessarily, devoted to interments in the free soil. In some churchyards where there is abundance of room, only one coffin is deposited in a grave; but in most cases, and particularly in the burial-grounds of large towns, the graves are dug very deep, and several coffins, sometimes as many as a dozen, or even more, according to the depth of the grave, are deposited one over another, till they reach within 5 or 6 feet of the surface. Interments in this manner are of two kinds. The first are made in family graves, in which the different members of the same family are deposited in succession, in the order of their decease; and to such graves there is always a grave-stone or some kind of monument. The second are what are called common graves, to which there is no monument, and in which the bodies of the poor and of paupers are deposited, in the order in which they are brought to the cemetery; probably two or three in one day, or possibly as many in one day as will fill the grave. Unless this mode were adopted in the public cemeteries, they would, from their present limited extent, very soon be filled up. Such graves, whether public or private, in the newly formed cemeteries, when once filled with coffins to within 6 ft. of the surface, are understood never to be reopened; but, in the old burial-grounds, they are in many cases opened after being closed only four or five years, and sometimes much sooner.

When the parties burying cannot afford to purchase a private or family grave, the practice is, in some burial-grounds, to bury singly in graves of the ordinary depth of 6 or 7 feet, and these graves are reopened for a similar purpose in six or seven years; but, as this is attended with the disinterment of the bones, it is a very objectionable mode. In a burial-ground properly arranged and managed, a coffin, after it is once interred, should never again be exposed to view, nor a human bone be disturbed. At present this is only the case in the cemeteries of the Jews, where there is a separate grave for every coffin, and where the graves are never reopened. It is also the case in the cemeteries of the Quakers; though not, we believe, from religious principle, as in the case of the Jews, but rather from that general regard to decency and propriety which is a characteristic of that sect of Christians, and perhaps, as in the case of the Moravians, in consequence of their comparatively limited number.

As *data* to proceed upon with reference to interments in the free soil, it is necessary to state that the muscular part of the body either decays rapidly, or dries up rapidly, according to the circumstances in which it is placed; but that the bones do not decay, even under circumstances the most favorable for that purpose, for centuries.

The face of a dead body deposited in the free soil is generally destroyed in three or four months, but the thorax and abdomen undergo very little change, except in colour, till the fourth month. The last part of the muscular fibre which decays is the upper part of the thigh, which in some subjects resists putrefaction for four or five years. In general, a body is considered unfit for dissection after it has been interred eight or nine weeks. In a very dry and warm soil, especially

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species of mummy is produced. This may be observed in the vaults of various churches in Britain where the soil and situation are remarkably dry; and it has given rise to those appalling scenes which may be witnessed in the vaults of Bremen, Vienna, Rome, Naples, Palermo, Malta, and other places. (See *Necropolis Glasguensis*, p. 48. to 55.; and Stephens' *Incidents of Travel*, as quoted in the *Saturday Magazine*, vol. xx. p. 141.)

Bones are chiefly composed of phosphate of lime deposited in gelatine, an animal tissue; and, unless acted on by powerful acids, they will endure, either in the soil or in the atmosphere, for many centuries. They are even found in the fossil state, and after ages of exposure often contain more or less of the original animal tissue, particularly if they have been embedded in clayey soil. In the antehominal part of the creation, there are bones daily discovered which have existed 6000 years at least. Dr. Charles Loudon informs us that he has seen numerous human bones in certain caves near to Naples, which are supposed to be those of the Grecian colonists who settled there before the Christian era, or perhaps those of an older race who inhabited Magna Græcia. Dr. Loudon has seen several skeletons dug out of the ruins of Pompeii, the bones of which were as dry and entire as the bones of skeletons which we see in dissecting-rooms, though they must have lain there nearly 1800 years under the lava, which, around them, seemed to be a dry greyish kind of earth. Even while writing this, we read in the newspapers (*Morn. Chron.*, Jan. 10.) of the workmen, while digging a deep sewer in Lad Lane in the city, having cut into what is supposed to have been a cemetery of the Romans, and dug up a number of human bones.

With respect to *prejudices*, there is, as every one knows, a decided prejudice in favour of being buried in dry soil, and against the placing of decomposing substances, such as quicklime, in coffins; and it is one of our principles to respect existing prejudices as well as vested rights. With regard to the use of quicklime; independently of the existing prejudices against its introduction into coffins, it is found to cause the solution of the softer parts of the body, which, unless the coffin is watertight, and this is rarely the case with the coffins either of the poor or of the middling class, oozes out to such an extent that the undertaker's men can scarcely carry the coffin, on account of the flow of matter and the odour.

The health of the living is chiefly affected by a certain description of gas, respecting which it is necessary to enter into some detail. The decomposition of the muscular part of the human body takes place with different degrees of rapidity in different soils, and at different depths in the same soil. It is most rapid in sandy soils somewhat moist, within 3 or 4 feet of the surface, and in a warm climate; it is next in rapidity in chalky soils; much slower in clayey soils; and slowest of all in peaty soil, saturated with astringent moisture. In general, dry soil, and a moderate distance of 5 or 6 feet below the

body will have become a black mould in between six and seven years; but, practically speaking, the bones may be considered as indestructible. In the progress of decay, the first change which takes place immediately after death, is the escape of a deleterious gas from the mouth and nostrils, but generally in so small a quantity as not to be perceptible for three or four days. In some cases, it is perceptible in a much shorter period; and in all, a gas accumulates within the body, which escapes sooner or later according to the progress of the putrescent process. If the body is buried in the free soil, in a wooden coffin, to the depth of 5 or 6 feet, the gas escapes into the soil, and is, in part at least, absorbed by it, and consequently does not contaminate the air above the surface; but, if a leaden coffin is used, and the body is deposited in a vault, catacomb, or brick grave, the gas escapes within the coffin, and either remains there till the coffin decays, or escapes through crevices in the lead, and through small holes bored on purpose by the undertaker in the outer wooden coffin and leaden inner coffin, and concealed by the name-plate. *(Report on the Health of Towns, Walker, &c.)* By the last mode the gas begins to escape before the corpse is taken from the house; and its effect is often felt there, as well as when the service is being read over it in the chapel, and even after it is deposited in a vault, the catacombs of which, though apparently hermetically sealed, are seldom air-tight. Sometimes the body, especially of a corpulent person, swells so much before it is removed from the house, that it is ready to burst both the inner and the outer coffin; and in that case it requires to be tapped, and the gas burnt as it escapes, or the operation performed close to an open window. Even in some of the public catacombs of the new London cemeteries explosions have been know to take place, and the undertaker obliged to be sent for in order to resolder the coffin; which shows the disgusting nature of this mode of interment, and its danger to the living. To inhale this gas, undiluted with atmospheric air, is instant death; and, even when much diluted, it is productive of disease which commonly ends in death, of which there is abundant evidence in Walker's *Grave-Yards*, and the Parliamentary Report quoted. The gas abounds to a fearful extent in the soil of all crowded burial-grounds, and has been proved to be more or less present in the soil thrown out of graves where bodies have been interred before. Even in the new London cemeteries, when interments are made in family graves, or common graves, which have been filled in with earth, such is the smell when the grave-diggers arrive within 2 or 3 feet of the last deposited coffin, they are obliged to be plied constantly with rum to induce them to proceed. This is more particularly the case when graves are dug in strong clay, because the gas cannot escape laterally as in a gravelly or sandy soil, but rises perpendicularly through the soil which has been moved. The remedy for this evil is, never to allow a family grave, or a common grave, in which an interment has been made, to be excavated deeper than within 6 feet of the last deposited coffin; and, to make sure of this, there ought to

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be a protecting stone, or slate, to be hereafter described, deposited when the grave is being filled, at the height of 6 feet above the last coffin, under a severe penalty. It is only by some regulation of this kind, that burying several coffins in deep graves can be conducted without injuring the health of grave-diggers; and without the gas, which escapes from the earth brought up, endangering the health of those who may be occasional spectators.

In the years 1782 and 1783, when the disinterment of the burying-grounds of Les Innocents in Paris, took place under the direction of some eminent French chemists, these philosophers endeavoured to analyze this gas, but were unable to procure it. Fourcroy, speaking in their name, says:—"In vain we endeavoured to induce the grave-diggers to procure any of this elastic fluid. They uniformly refused, declaring that it was only by an unlucky accident they interfered with dead bodies in that dangerous state. The horrible odour, and the poisonous activity of this fluid announce to us that if it is mingled, as there is no reason to doubt, with hydrogenous and azotic gas holding sulphur and phosphorus in solution, ordinary and known products of putrefaction, it may contain also another deleterious vapour, whose nature has hitherto escaped philosophical research, while its terrible action upon life is too strikingly evinced. These Paris grave-diggers know," Fourcroy adds, "that the greatest danger to them arises from the disengagement of this vapour from the abdomen of carcasses in a state of incipient putrefaction." (See *Annales de Chimie*, vol. v. p. 154, as quoted in Walker's *Grave-Yards*, p. 86; and Ure's *Dictionary of Chemistry*, art. Adipocere.)

While this inflation from gas is going forward, the aqueous part of decomposition, a "fetid sanies," exudes from the body, and sometimes, when interment is delayed too long, to such an extent as to drop from the coffin before it is taken out of the house. This exudation, as already observed, is greatly accelerated and increased by putting quicklime into the coffin. In the free soil this feted sanies is diffused by the rain into the subsoil, and carried along in the water of the subsoil to its natural outlet, or to the wells which may be dug into it; and thus, while the gas of decomposition poisons both the earth and the air, the fluid matter contaminates the water.*

* Speaking of the infectious agency in the houses in the neighborhood of that part of London called Fleet Ditch, Dr. Lynch observes:—"The great primary cause is, that the privies are in general under the staircase of the wretched hovels of the poor, and the sulphuretted hydrogen, and the carbonated hydrogen, and the noxious gases there generated, are the same gases as are generated from the dead bodies in a state of decomposition; for the evacuations from the body are decomposed animal and vegetable matter, and a dead body is the same, it is decomposition of the dead body, or a general state of disorganisation, and that produces exactly the same kind of gases. There have been instances mentioned, where people have fallen down dead from a rush of those gases in a concentrated form." (*Report on Health of Towns*, &c., p. 161.)

If the public were fully aware of the dangerous nature of the gases which proceed from the decomposition of dead bodies in crowded churchyards, and in vaults and catacombs, and of the poisonous nature of the water of decomposition:

1. They would not live in houses bordering on churchyards, which, though already full, are still used as burial-grounds.

2. They would not drink the water of wells dug in the vicinity of burial-grounds, whether

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With regard to the *destruction of human bones*, we assume that to be impracticable, otherwise than by means which are altogether out of the question. The most favorable soil for their decomposition is a coarse gravel, subject to be alternately moist and dry; but, though such a soil, so circumstanced in regard to water, might be found naturally, or might be composed by art, yet these cases may be considered as equally impracticable. Instead, therefore, of endeavouring to destroy the human skeleton, let us limit our endeavours to preventing it from being desecrated by disinterment and exposure. This may be effected in various ways; but by far the most simple, effectual, and economical, as it appears to us, would be to place over the coffin, after it was deposited in the grave, a stone or slate of the same dimensions as the coffin, or even as many flat 12-inch tiles, say six, as would extend from head to foot. As the coffin and the muscular part of its contents decayed and sunk down, the stone, slate, or tiles, would follow it and press close on the bones. In consequence of this arrangement, when the ground was at any future period opened to the depth of the stone, slate, or tile, guard, it would be known that a skeleton was beneath, and the operator would cease to go farther; or, at all events, it should be rendered illegal for him to do so. If a name and date were graven in the stone, being protected from atmospheric changes, it would remain uninjured for ages, and, like the foot-marks which geologists have found in the red sandstone, might, in some far distant age, become part of the geological history of our globe. We prefer stone or tile guards, to guards of metal, because iron would soon rust, and cease to be a guard, and lead or any equally durable metal would offer a temptation to stealing. A layer two or three inches thick of stucco, Roman cement, or a plate of asphalte or oropholithe, might be used as a substitute; but stone, slate, and tiles are decidedly preferable. The slate might even be introduced within the coffin, without rendering it heavier to carry than if a lead coffin were used. Burying in a coffin made entirely of stone or slate we do not consider so likely to prevent desecration as a stone or slate guard; because there is a temptation to dig up the lower part of the stone coffin, and use it as a drinking-trough for cattle, or a cistern for a flower-garden, which is done in various places in the vicinity of old abbeys. A stone hollowed out on the under side might be better than a flat stone; because the depending edges would be a kind of side protection to the skeleton; and might, to-

in town or country; because, though the filtration of the soil will purify the water from matter suspended in it, it will not free it from what is held in solution.

3. They would not attend service in any church or chapel whatever, in the vaults of which there were coffins, or in the floors of which interments had taken place. They would absent themselves from all such places, even if there were no immediate danger, in order, by such means as were in their power, to contribute to the discountenance of a practice by all parties allowed to be attended with disgusting and injurious results.

4. Nor would they live in houses in which the privies were not either rendered water-closets, or placed detached from the house.

5. Nor in a house adjoining an open sewer.

6. Nor would they keep a dead body in the hou·e more than five days, or at the most, a week.

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cavating for improvements.

The *space of ground required* for a single interment, and for the interments incident to any given population, requires next to be taken into consideration. If all interments took place in the free soil, if a grave were allowed for each coffin, and the grave were never afterwards to be opened, that is, not opened for several generations, then the space required for cemeteries would be considerable. Thus, supposing graves without head-stones or ornaments of any kind to occupy a surface of 7 ft. by 3 ft. 6 in., and the average area of those having grave-stones or monuments to be 10 ft. by 5 ft., then, making an allowance for grass paths between the graves, and for gravel roads, we may take 8 ft. by 4 ft. as the average space on which to calculate the capacity of a garden or ornamental cemetery. This will give 1361 graves to an acre; and, estimating the deaths in a town population at 3 per cent. per annum, this acre would suffice for a population of 1000 souls for 45 years; or for a population of 45,000 for one year. Taking the population of London to be 1,500,000, this would require 33 acres annually, or the whole of that part of Middlesex not covered by London and its suburbs (128,540 acres) in the course of 3895 years. The average number of deaths annually in England and Wales has been ascertained to be about 336,000, which, at 1361 interments to an acre, would require 247 acres annually; or, supposing three interments in each grave 82 acres per annum. On the supposition that ground once occupied by graves was forever afterwards to be held sacred, and not subjected to cultivation of any kind; the mode of interment which would require so large a sacrifice of surface annually may be considered as impracticable; and, for our present purpose, this is the view we shall take of it. We shall, however, hereafter show how separate graves may be procured, not only for those who cannot afford grave-stones, but even for paupers; and these graves never again opened for generations. In the meantime, the mode of burying several coffins in one grave, provided these coffins are of wood, and layers of soil not less than 6 ft. in thickness interposed, and the graves, when once filled, not opened for generations, appears the best adapted for the present state of things. Supposing that on an average three interments take place in each grave or vault before it is finally closed, this will give upwards of 4000 interments to the acre; and, as the eight public cemeteries recently formed in the neighborhood of the metropolis, and the unoccupied part of the new burial-grounds recently formed by different sections of the Dissenters, contain upwards of 300 acres inclusive of the space occupied by roads and buildings, this will probably supply the demand for two centuries to come, even allowing the population to increase.

The *security of the grave* was, till within these few years, an important part of the considerations requisite to be had in view in constructing cemeteries. In some cases it was effected by surrounding the enclosure by high walls, or other effective fences; sometimes by

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constructing central watch-towers for stationary watchmen within; sometimes by employing perambulating watchmen; at others by burying in a grave 15 or 20 feet deep; by burying in a walled grave, covered with an iron grating built into the walls all round, some feet beneath the surface soil, and keeping the surface loose, and planted with flowers or shrubs (which, as the grave could not be disturbed without first taking these up, would by their withered state, when replanted, have told what had been attempted); and sometimes by the very extraordinary mode of letting down over the coffin a ponderous cast-iron box, to remain over it for six or eight weeks, till the body was considered to be so far decomposed as to be unfit for the purposes of the anatomist. The iron box, or case, which had remained whelmed over the coffin, but without touching it, was then disinterred and drawn up by machinery, and the wooden coffin was covered with soil, and the grave completed a second time in the usual manner. Even the poorest families, in some parts of Scotland, went to this extraordinary expense. Fortunately a law has been passed which render these precautions unnecessary, and we shall therefore take no further notice of them.

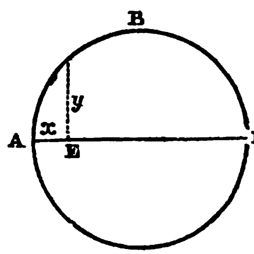
(To be continued.)

Mechanics and Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Steam Boilers.

The circle A B D represents the section of a cylindrical boiler, and it is required to determine its resistance to the pressure of the steam.



Although the pressure is necessarily equal in every point of the periphery, and its direction every where normal to the surface of the cylinder, in consequence of inequalities in the strength of the material, the boiler is most likely to give way at some one point, D for instance, and to open by turning around some other point as a centre of motion. Let A be this turning point, and let us put

F for the force of steam on a unit of the periphery;
x and y for the co-ordinates of the point m, and
δ for the diameter of the cylinder.

Then $F\frac{dx}{ds}$ will represent the force of the steam perpendicular to the line A D on a unit of the periphery of the boiler at the point m, and $F\frac{dx}{ds}ds$ the same force for the space ds. The leverage with which this force acts to turn the section around the point A, is x, and, conse-

quently, the *moment* of this differential force with reference to the point A is

$$F\, x \frac{dx}{ds}\, ds.$$

The horizontal component, or that component of the force at m which is parallel with the line A D, for the space ds will be $F \frac{dy}{ds}\, ds$, and its moment, with reference to the same point A,

$$F\, y \frac{dy}{ds}\, ds.$$

The integral of the sum of these differential quantities, taken between the limits $x=o$ and $x=\delta$ will give the whole moment with reference to A; which integral is expressed by

$$\int F\, x \frac{dx}{ds} ds + \int F\, y \frac{dy}{ds} ds = \frac{F\, \delta^2}{2},$$

observing in the operation, that $2\, y\, dy = d.\, (\delta x - x^2)$.

Now, "if P be the cohesive force of the metal of the boiler, and t the thickness of the shell in inches," Pt will represent the resistance which the boiler will offer at D, and $Pt.\delta$ the *moment* of this resistance with reference to the point A; which moment, in the condition of equilibrium, must be equal to the tension, or

$$\frac{F\, \delta^2}{2} = Pt\, \delta;$$

and, consequently, we have for the extreme force per inch which the boiler will bear,

$$F = \frac{2\, Pt}{\delta}$$

as given by Mr. Latrobe in the last number of the Journal.

We may, if we choose, suppose the material in opposite parts of the section of the boiler, as at A and D, to possess the same strength, so that the rupture will take place at both those points simultaneously,—the upper and lower parts of the cylinder being driven asunder,—and thus avoid introducing the *moment* of the force.

In this case the above integral will be simply

$$\int F \frac{dx}{ds}\, ds + \int F \frac{dy}{ds}\, ds = F\, \delta,$$

for the expression of the whole tension of the steam of which the effect is to part the boiler at A and D. The resistance which the shell will offer at *each* of those points is Pt—whence the equation of condition

$$F\, \delta = 2\, Pt.$$

and, consequently, as before,

$$F = \frac{2\, Pt}{\delta}$$

the equation given by Mr. Latrobe in the last number of the Journal.

E.

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Iron-Founding.

SECTION I.—The general object of iron-founding is, to mould iron in a melted state into the various forms required for the parts of machines and other constructions. Wrought iron and steel cannot be properly melted by heat. At high temperatures, they drop away and spark off, while the main body of the metal maintains its consistency, and it undergoes rapid oxidation, as is shown by the scales which are perpetually formed on the surface. These metals are, however, in this condition rendered extremely ductile, and the wrought iron especially may be fashioned with facility into any required form by the application of the hammer. On the contrary, pig iron, of which wrought iron and steel are preparations, has peculiarly the property of liquefaction by heat, and is therefore well adapted as a material for castings, in which strength and hardness are required.

The business of the iron-founder is therefore to take advantage of the common law, according to which fluids always find their level. If, for example, a quantity of water be poured into a vessel, however curiously shaped, it first finds the bottom, and then spreads on all sides as it rises, filling every corner it can reach. The body of water must then be a perfect model in form of the interior of the vessel, and this may be seen by solidifying it in its place by the application of cold, and extracting the body of ice.

To mould a quantity of melted iron into any desired form, two things are therefore necessary; first, a model or pattern of the required form; secondly, a substance of sufficient susceptibility and adhesiveness, to receive accurately, and to retain impressions, of that pattern made upon it, against the violence of the liquid iron, when run into the mould which is thereby formed.

Of Patterns.—As to the material of patterns, wood is almost universally employed—yellow pine and mahogany being the kinds principally used. Of these, yellow pine is by far the most in common use. It is very suitable, being very uniform in substance, little interrupted with knots, sufficiently hard, works cleanly and with ease, and, moreover, there is plenty of it. Mahogany does excellently for small patterns, but its expense limits its application to the construction of these. It can be cut very clean, and its superior density and closeness of grain render it well fitted for nice patterns, such as of bushes for journals, small pinions, the teeth of wheels below 1 in. pitch, and in every case of a similar nature, in which the fibres of the wood may be presented endwise to the surface; whereas in working fir in this manner for minute purposes, it is apt to be broken away at the edges.

Plane-tree, beach, and red-pine are seldom used. Plane-tree has a very fine and agreeable tissue, and is very suitable for sharp, well-defined patterns, and small patterns intended for constant use, as it retains its sharpness for a long time. Red pine is remarkable for its toughness and straitness of grain, but it is coarse in the fibre. It is only employed for pinning together pieces of wood of deficient dimen-

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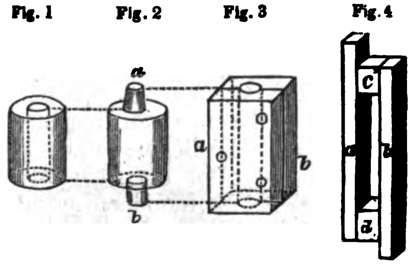
erly much used for patterns, but it has long been almost entirely dismissed as a material for such a purpose, on account of the roughness of its cross-cut.

After an original wood pattern is made, for purposes of light flat moulding, an iron pattern is cast off it, from which afterwards all the moulds are made, as the iron one lasts longer by a great deal than the other, and will preserve its form, which, in a wooden one, is liable to alter in the course of time, especially if the pattern be slender, and the material not thoroughly dry. Tin is frequently used instead of iron, chiefly for patterns of ornamental work, as it can much more readily be cleaned up and smoothed for service. To preserve wood patterns from the effects of damp, a coat of paint ought to be given them, and this is very serviceable in moulding the patterns of wheels, for even during the time of being amongst the sand, which is always damp, the teeth, especially those of smaller pitch, are liable to swell, and have their form destroyed. And as patterns are frequently made of wood not thoroughly dry, they shrink afterwards as they become drier; and those especially which have great extent in proportion to their thickness, such as patterns for plates, will twist at right angles to the direction of the grain, in consequence of the unequal shrinking of the opposite sides. To prevent them from altering their form, bars of wood are nailed across them, which of course leave their impressions in the sand; and it is the care of the moulder to fill these up.

Use of Patterns.—The construction of patterns requires from their nature in many cases to be modified, so as to render the moulding of them practicable. For example, for castings in which recesses or holes passing quite through them, are wanted, it is easy to see that were the space, in many cases actually made in the pattern, to be afterwards occupied by the sand of the moulding, it would carry off the *core* of sand as it is called, altogether. The making of these holes must be provided for in another way. Distinct cores are made by other means, having exactly the dimensions of the hole required in the casting, and that they may be securely held in their positions in the moulding, their ends project into counterpart holes in the sand, and are there fixed. These holes are formed by corresponding projections made in the pattern, named *core-prints*. For example, were it required to cast a coupling for shafts, of a cylindrical form, 12 inches deep, by 8 inches diameter outside, and 4 inside diameter, as sketched (fig. 1), a pattern of the same size, (fig. 2) is made, and two prints, *a*, *b*, are put on, in the proper positions to support the core; this is made of sand in a *box*, shown by fig. 3, which is simply two thick pieces of wood, *a*, *b*, held together by wooden pins. Into each of these, half the core hole is cut, so that when

Fig. 1 Fig. 2 Fig. 3 Fig. 4



the core is formed in it, it may easily be got out by separating the

halves. If then after the pattern (2) has been moulded, the core formed in the box (3) be inserted in the recesses left for it by the prints, the casting (1) will be formed, which otherwise would have been solid; for, were a pattern made like fig. 1, with the hole made through it, on withdrawing it from the sand, it would, most likely, carry off the *core* with it. In this instance, indeed, with much care on the part of the moulder, he might have managed to leave the core in its position unbroken, on account of its considerable diameter; but if it had been much smaller, say 2 inches, it could not have stood the tug of the pattern, and much less the shock of the melted iron. But, further, it is quite impracticable when the core lies horizontally, as the pattern in being withdrawn would, of course, unavoidably lift it away.

Thus, by means of distinct cores formed by boxes, holes and recesses of every kind are made in castings, if they be not already formed in the pattern.

Square cores are formed by two slips of wood, *a*, *b*, fig. 4, of the required thickness, and kept apart at the ends, by two pieces *c*, *d*, forming, by filling the space within with sand, the core required. It is, however, foreign, to our present purpose to describe the construction of patterns, further than is necessary to the elucidation of the subject under consideration.

Materials used in Moulding.—The principal materials used in the various branches of moulding, are sand of various kinds, clay, blackening, coal-dust, and cow-hair.

Sand is superior to all other substances as a material for forming moulds generally. For, in the first place, the hot iron has no chemical action upon it, though certainly it acts upon the matters which it is found necessary to associate with it, namely, blackening and coal. But secondly, it operates well as a conducting medium for the air expelled from the space filled by the iron, and for the other gases generated by the action of the heat on the blackening and the coal. And thirdly, it possesses considerable adhesiveness when rammed together —sufficient indeed, to make it retain its form against the pressure of the melted iron; and, moreover, it is easily made to conform itself very accurately to the surface of the pattern imbedded in it.

The sand of the London basin is the finest in the country. It is universally employed in the manufacture of fine goods, as grates, fenders, and the like. The sand in the neighborhood of Falkirk is coarser and opener in the pores, which unfits it for such work. It is employed for casting hollow ware—pots and kettles, for example, as the inclosed air escapes freely through the inside body of sand in the moulding of such articles. It affords a beautiful, smooth skin to the castings from Scotch iron, so remarkable in the hollow goods of the Carron Iron Works, in Stirlingshire, and of the Phœnix Iron Works, at Glasgow. The Belfast sand is finer than that from Falkirk, and is used principally for fine machinery castings. It is also sometimes used for facing the moulds of ornamental work, to give a fine surface. It is besides excellent for hollow moulding, when mixed with the Falkirk sand; but it is too expensive for general adoption in that way. It is a mixture of a very fine adhesive sand, and an opener

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kind. Rock-sand, the debris of abraded rock, and free-sand from the sea-shore are employed for making cores. The former, by itself, does very well for short cores, which open into the sand of the mouldings at both ends, as it contains a proportion of clay in its composition, which gives it cohesion. But it requires to be moderated with free-sand, to make it opener for the better escape of the air in its pores, when used for cores of considerable length, which, of course, are surrounded on all sides by the iron, except at the small portions at the extremities, by which alone the air can find exit. Free sand is also used alone for such cores, but as it wants adhesiveness, it requires to be tempered with clay water, barm, or the refuse of pease meal. In the use of the last, accuracy is required in proportioning it. The first is used in ordinary cases, and the barm only in very particular cases.

Clay is also very much employed, when mixed with sand, for loam-moulding. These ingredients are ground together with water, to give them consistency, and their proportions generally are one part of clay to eight or nine parts of sand. This, with a handful of hair mixed with it, forms ordinary *loam;* and a shovelful of horse-dung, seeds, or saw-dust, is added for *core-loam.* The purposes of these minor elements will be afterwards referred to.

Blackening and coal-dust are employed to resist the penetrating action of the iron on the sand. Blackening is simply charred oak wood ground to powder. Oak charcoal is superior to all the other ordinary wood charcoals for the purpose, as it is the heaviest. Other wood charcoals are apt to be disengaged from the surface of the mould to which they are applied, and to float in the iron while liquid, which of course defeats the object of their use. According to Mr. Mushet's experiments, oak produces 22.6 per cent., that is, fully one-fifth of its weight of charcoal. Were the iron allowed to come into direct contact with the sand of the mould, it would enter its minute interstices, and thus yield but a rough surface. To avoid this, blackening is dusted over the surface of the mould, pressed down on it, and smoothed, in cases of green sand castings, but it is mixed with clay-water, for covering loam-mouldings. Its essential property as a protector of the sand, is its inflammability. All combustible solid substances peculiarly resist liquid iron, as may be exemplified in pouring it over a smooth surface of wood. It rolls about as lively as mercury, on account of the continued effusion of gaseous matter by the combustion of the wood heaving up the iron from the surface. Now, in cases of heavy castings in green sand, as the action of the metal becomes too powerful for the blackening, this is assisted by coal-dust, which is mixed uniformly in the sand. It is never more than one-tenth of the sand in bulk, and the best kind of coal for the purpose, is the rich, hard, splint coal.

Kinds of Moulding.—The art of moulding may be divided into two great divisions; namely, green and dry-sand moulding, and loam-moulding. In the first division, patterns of the articles wanted are universally employed in forming the mould; in the second division, the ordinary patterns are dispensed with, the objects of this division being heavy castings of a regular form; as cylindrical bodies gener-

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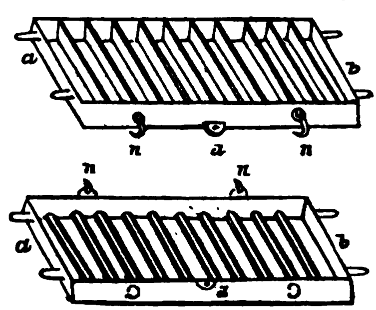
ally, and other circular ware, such as sugar-pans and gas-retorts. Large square vessels, water-tanks, for example, may also be made by a process of loam-moulding. The first division again embraces every other variety of article, for which there must be patterns. Dry-sand moulding is generally employed for the making of pipes, columns, shafts, and other long bodies of a cylindrical form. It is firmer and better adapted to purposes of this kind than green sand. The material of dry sand, is the loam already used in loam-moulding, called *pit-sand,* mixed in the mill with an addition of rock-sand. It is named dry-sand, in contradistinction to green-sand, because, after being moulded, it must be dried by heat to fit it for the purpose; whereas the latter is employed as it comes from its native bed, new and damp; the dampness indeed is assisted afterwards when necessary, as a certain degree of it is always requisite.

The operations of green-sand moulding are generally recognised under two great classes—hollow moulding, and flat moulding. The former includes pots, frying-pans, and every other kind of cooking ware, of a light dished form. The latter class is very extensive, and is so termed in opposition to hollow-moulding. It includes all objects of a flat nature, the various parts of grate furniture, for example, and other ornamental work generally, stoves, roans, smoothing-irons, all kinds of machinery that do not fall under loam and dry-sand moulding, for instance, all the cast-iron work of spinning and loom machinery. In fact, a kind of subdivision exists, known as job-moulding —a homely term, including machinery generally, and the heavier kind of work, distinguishing them from the ornamental and the other lighter work. A steam-engine affords in the parts of it, examples of the three kinds of moulding. The steam-cylinder and the air-pump which are round, and the condenser, which is often square, are instances of loam-castings,—the fly-wheel shaft, and the single columns supporting the framing are examples of dry-sand castings, and the beam, sole-plate, entablature, and connecting rod, if of cast-iron, are referable to the heavier green-sand casting. The cistern plates, too, are decided instances of flat-moulding.

Processes and Tools.—The processes of green-sand moulding, and the tools employed in it, claim our first attention. In processes of green and dry-sand moulding, boxes are always employed, the purpose of which is, to contain the sand in which the pattern is moulded. These boxes are for convenience of various sizes. If there be a great or constant demand for castings of one form, boxes are made expressly for them, corresponding in form. By this plan, a saving of labour is effected, as the ramming up of useless corners with sand is avoided. For general purposes, boxes are made rectangular, and in two halves, as shown in the sketch annexed. These boxes have neither top



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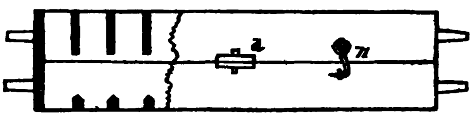
nor bottom, but each half-box, or more correctly each box, is composed of an outside rectangular frame *a*, *b*, which is generally 3, 4 or 5 inches deep for the lighter flat-moulding. They have transverse ribs joining the opposite sides at equal distances of 4½ inches between them. The object of their being open on the upper and under sides is, to allow the application of the tools for ramming the sand in the box; the ribs being at the same time sufficient as holding surfaces for the sand, which is formed into a close adhesive mass by the ramming, and, in a manner, dovetailed into the ribs. The rougher, therefore, these boxes can be made, the better—they hold the sand more effectually, and, accordingly, in casting the boxes themselves, the patterns for them are simply laid in the sand on the ground, and after being rammed, are drawn out. There is no blackening used for the surfaces of the moulding, and thus the iron enters the pores of the sand, and roughens.

As there is no covering for the mould, it being exposed to the air, this mode of casting is named open-sand casting. The exposed surface is made, however, very irregular and rough, so that this mode of casting is used only for moulding boxes, when the roughness is a virtue, and for articles of a coarse nature.

The figure annexed is a longitudinal view and partial section of a pair of boxes, in which it is seen that the ribs of the upper box are not so deep as the outside frame. They are generally an inch less deep to allow a depth of sand over the pattern that is imbedded in the sand



of the lower box. The frame of this box, called the drag-box, is the same as that of the upper, but the ribs are much shorter and thicker, as it is not required to be moved about and inverted like the upper one; besides, it allows much more available depth of space for the moulding of the pattern. As the lifting and shifting of these boxes, when small, is usually managed by two men, they have two snugs or handles at each end, seen in the first figure, by which they are held. They have also usually three hooks and eyes, *n*, *n*, and three pins and holes to receive them, arranged alternately along the sides, there being two on either side, and one over the other. The pins are fixed on ears, *d*, *d*, *d*, cast on the sides of the drag box, and pass through holes made in ears on the upper box, which correspond, so that the boxes in being placed and replaced together, must have always the same relative position. The hooks and eyes hold them tightly together for casting.

The sketches annexed represent the different kinds of tools employed by flat-moulders in the execution of thin work. No. 1, is the trowel—the instrument in most frequent use by moulders. There are various sizes of it used, from ¼th to 2 inches broad in the blade, and 3 inches long generally. The purpose of the trowel is to clean away and smooth down the surface of the sand, to press down and polish the blackening, repair injured parts of the moulding, and so

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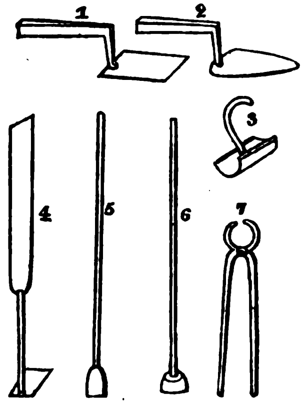
ularly employed for entering acute angles in a moulding, into which the square trowel evidently cannot go. No. 3, is another form of tools for managing hollow impressions in the sand. No. 4, is the form of the sleeker and cleaner. As the trowel is applicable only to open plain surfaces, this tool is used for cleaning and smoothing sunk surfaces in the sand which the ordinary trowel cannot reach—as the impression of a flange, or of any flat part of a pattern presented edgewise to the sand. The upper end is applied to the sides of such an impression for sleeking or smoothing it, and the under end goes to the bottom, where it is used both for taking up loose sand lying there, and for pressing and smoothing down the surface. It is to be noticed too, that the upper end is presented edgewise to the direction of the *spade* at the under end, so that when this is employed at the bottom of a deep recess, the upper end stands sideways to the side of the recess and permits free motion. No. 5, is the first rammer; it is about 4 feet 6 inches long, and its under face is about 2 inches + 1 inch. Sometimes the upper end, by being tapered off, is made to serve for forcing holes in the sand. No. 6, is the second rammer for finishing the work of the first. It is round in the face, about 3½ inches diameter, with a wooden shank of convenient length. No. 7, represents the pincers used for laying hold of and shifting about the castings. They have no peculiarity except in having their holding faces round and flat.



Besides these tools, shovels are used for working the sand, sieves and riddles for refining it, and bellows for blowing off loose sand from mouldings; pots for holding the parting sand and the water used in moulding, swabs for applying this water to the mouldings, being simply tufts of tow brought to a point, and separate linen bags of pease-meal and blackening, through the texture of which these materials are shaken on the sand. There are also piercers or "prickers," as they are named, being pieces of thick iron wire sharpened at one end to a point, for piercing the sand to let off air.

To be Continued.

"*An Experimental Inquiry as to the Co-efficient of Laboring Force in Overshot Water-wheels, whose diameter is equal to, or exceeds, the total descent due to the fall; and of Water-wheels moving in circular Channels.*" By Robt. Mallett, M. Inst. C. E.

This paper is partly mathematical, and partly experimental. The investigation which it details, the results of which are given in ten

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tables of experiments, had in view, principally, to obtain the definite solution of the following questions.

1st. With a given height of fall and head of water, or, in other words, a given descent and depth of water in the pentrough, will any diameter of wheel greater than that of the fall give an increase of laboring force (*i. e.* a better effect than the latter), or will a loss of laboring force result by so increasing the diameter?

2nd. When the head of water is necessarily variable, under what conditions will an advantage be obtained by the use of the larger wheel, and what will be the maximum advantage?

3rd. Is any increase of laboring force obtained, by causing the loaded arc of an overshot wheel to revolve in a closely fitting circular race, or conduit? and if so, what is the amount of advantage, and what the conditions for maximum effect?

The author briefly touches upon the accepted theory of water wheels, the experimental researches of Smeaton, and the recent improvements in theory, due to the analytic investigations of German and French engineers.

Smeaton, in his paper on water wheels, read to the Royal Society in May, 1759, and Dr. Robison, in his treatise on water wheels, lay down as a fixed principle, that no advantage can be obtained by making the diameter of an overshot wheel greater than that of the total descent, minus so much as is requisite to give the water, on reaching the wheel, its proper velocity.

The author, however, contends that while the reasoning of the latter is inconclusive, there are some circumstances which are necessarily in favor of the larger wheel, and that conditions may occur in practice, in which it is desirable to use the larger wheel, even at some sacrifice of power; and that hence it is important to ascertain its co-efficient of laboring force, as compared with that of the size assigned by Smeaton for maximum effect.

The author states, first, the general proposition, "that the laboring force ("travail" of French writers,) or "mechanical power" of Smeaton, of any machine for transferring the motive power of water "is equal to that of the whole moving power employed—minus the half of the *vis viva* lost by the water on entering the machine, and minus the half of the *vis viva* due to the velocity of the water on quitting it." He deduces from the theory, the following results, coinciding with the conclusions obtained by experiment.

1st. If the portion of the total descent passed through by the water before it reaches the wheel be given, the velocity of the circumference should be one-half that due to this height.

2nd. If the velocity of the circumference be given, the water must descend through such a fraction of the whole fall before reaching the wheel, as will generate the above velocity.

3rd. The maximum of laboring force is greater, as the velocity of the wheel is less; and its limit, theoretically, approaches that due to the whole fall.

General equations are given, expressing the amount of laboring force in all the conditions considered, and their maxima.

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One of the principal advantages of using an overshot wheel greater in diameter than the height of the fall, is the power thus afforded, of rendering available any additional head of water occurring at intervals, from freshes or other causes, by admitting the water upon the wheel at higher levels.

The first course of experiments is dedicated to the determination of the comparative value of two water wheels, one of whose diameter is equal to the whole fall, and the other to the head and fall, or to the total descent; by the head, being in every case understood, the efficient head, or that due to the real velocity of efflux at the shuttle, as determined according to Smeaton's mode of experimenting.

The apparatus employed in this research consisted of two accurately made models of overshot wheels, with curved buckets. These were made of tin plate, the arms being of brass, and the axles of cast iron. Special contrivances were adopted to measure the weight of water which passed through either wheel during each experiment, to preserve the head of water strictly constant, and to determine the number of revolutions, and the speed of the wheels.

One wheel was 25.5 inches diameter, the other, 33 inches diameter. The value of the laboring force was determined directly, by the elevation of known weights to a height, by a silken cord over a pulley; the altitude being read off on a fixed rule placed vertically against a lofty chimney; and in other experiments, relatively by the speed of rotation given to a regulating fly or vane. The depth of the efficient head was 6 inches in all cases.

The weight of water passed through either wheel in one experiment, was always 1000 pounds avoirdupoise.

All the principal results given in the table accompanying the paper, are the average of five good experiments; from the large scale upon which these were conducted, the accurate construction of the apparatus, and the care bestowed upon the research, which was undertaken with reference to an actual case in the author's professional practice, he is disposed to give much confidence to the results.

The weight of water contained in the loaded arc of each wheel is accurately ascertained, and in the tables which accompany the paper, the results of the several experiments are given at length.

The velocity of the wheels, under different circumstances, is carefully noted and discussed with respect to the maximum force.

The author next ascertains the value of the circular conduits, and states that generally, in round numbers, there is an economy of laboring force, amounting to from 8 to 11 per cent. of the power of the fall, obtained by the use of a conduit to retain the water in the lower part of the buckets of an overshot wheel, whose diameter is equal to the fall. The velocity of a water wheel working thus, may vary through a larger range without a material loss of power, and a steady motion is continued to a lower velocity than when it is working in a free race.

The author finally arrives at the following general practical conclusions:—

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1st. When the depth of water in the reservoir is invariable, the diameter of the water-wheel should never be greater than the entire height of the fall, less, so much of it as may be requisite to give the water a proper velocity on entering the buckets.

2nd. When the depth of water in the reservoir varies considerably and unavoidably, an advantage may be obtained by applying a larger wheel, dependent upon the extent of fluctuation and ratio in time, that the water is at its highest and lowest levels during a given prolonged period; if this be a ratio of equality in time, there will be no advantage; and hence, in practice, the cases will be rare when any advantage will obtain by the use of an overshot wheel, greater in diameter than the height of fall—minus, the head due to the required velocity of the water reaching the wheel.

3rd. If the level of the water in the reservoir never fall below the mean depth of the reservoir, when at the highest and lowest, and the average depth be between an eighth and a tenth of the height of the fall, then the average laboring force of the large wheel will be greater than that of the small one; and it will, of course, retain its increased advantage at periods of increased depth of the reservoir.

Dr. Robison's views, therefore, upon this branch of the subject, should, he contends, receive a limitation.

A positive advantage is obtained by the use of the conduit varying with the conditions of the wheel and fall, of nearly 11 per cent. of the total power.

The value increases with the wheel's velocity up to 4½ feet per second, or to 6 feet per second, in large wheels. Hence, he argues, that it is practicable to increase the efficiency of the best overshot wheels, as now usually made, at least 10 per cent. by this application. The only objections urged against the use of the conduit are of a practical character, relating to the difficulty of making it fit close, of repair, &c.; but however these may have applied to the rude workmanship of the older wooden wheels, with wood or stone conduits, they are unimportant, as referring to modern water-wheels made of iron. The conduits may be also made of cast-iron, provided with adjusting screws, and hence of being always kept fitting, readily repaired, and capable of being withdrawn from the circumference of the wheel in time of frost, &c.

The paper is illustrated by a drawing, showing the elevation and partial sections of the experimental apparatus, and a diagram showing the full size of the loaded arc of each model.

Mr. Farey observed, that the result arrived at by the experiments, appeared to correspond nearly with those recorded by Smeaton, who had experimented upon, and used practically, both kinds of wheels. The buckets of the model wheels used in the experiments did not appear to be of the best form, and they were entirely filled with water; hence an apparent advantage had been obtained, by the use of the circular conduit to retain the water in the buckets. But that would not be realized in practice, for as the form of the bucket regulated the point at which the water quitted it, and it was the practice of the modern millwrights to make the wheels very broad, in order that the

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buckets should not be filled to more than one-third of their depth, the circular conduits became less useful, and in fact were now seldom used. Smeaton's practice was, to entirely fill the buckets with water, but he never adhered to the slow velocity of revolution which he recommended theoretically in his paper to the Royal Society.

Mr. Fairbairn had adopted broad wheels with an improved form of bucket, partially filled, and had obtained a more regular motion, particularly at high velocities.

Mr. Farey promised to present to the Institution, a copy of the method of calculation adopted by Smeaton for water-wheels.

Mr. Taylor corroborated Mr. Farey's statement of the advantage of using broad wheels, with the buckets of a fine pitch and partially filled; circular conduits then became unnecessary: this was practiced among the millwrights in North Wales with eminent success, and a velocity of six feet per second was given to the wheel.

Mr. Homersham believed that in Smeaton's latter works he increased the velocity of his wheels to six feet per second.

Mr. Rennie gave great credit to the author for the ingenuity of the apparatus with which the experiments were tried, and for the clearness of the tabulated results; but owing to the necessary limited size of the model wheels, he feared the results could not be relied upon for application in practice to large wheels. The experiments of Borda, Bossut, Smeaton, Banks and others, were all liable to the same objection.

The best modern experiments are those by the Franklin Institute, by Poncelet, and by Morin.

The result of these might be thus:

Undershot wheel,	the ratio of	power to	effect	varied from	0.27 to 0.30
Breast wheels,	"	"	"	"	0.45 to 0.50
Overshot wheels,	"	"	"	"	0.60 to 0.80
Average,	"	"	"	"	0.60

The velocity of the old English water-wheels was generally about three feet per second; the American wheels four feet, and the French wheels six feet: this latter speed was now adopted by the best millwrights in England. Mr. Hughes, at Mr. Gott's factory at Leeds, and Mr. Fairbairn, had found advantage from it; the latter also had a particular contrivance for carrying off the air freely from the buckets.

It was important to regulate the thickness of the sheet of water running over the shuttle upon the wheel; four to five inches was found in practice to be the maximum depth allowed.

The object being to utilize the greatest height of fall and the greatest available quantity of water, by means of properly constructed openings and such sluice-gates as were first introduced by the late Mr. Rennie for the breast-wheels constructed by him, instead of penning up the water in a trough, it was made to flow in a sheet of regular thickness over the top of the shuttle, and by a self-regulating apparatus to adjust itself at all times to the height of the water; thus obtaining the advantage of the full height of the fall at its surface, and obviating the necessity for the apparatus proposed by Mr. Mallett.

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respect to the form of the bucket, that used by him could not, he contended, be called a bad form, although it might be susceptible of improvement; but as the experiments were altogether comparative, it was foreign to the question whether the form was bad or good, the same having been used in both wheels.

As it was shown that a certain relation subsisted between two water-wheels with the same total descent, but with different diameters, as to their co-efficient of laboring force, a proportional relation would exist with any worse or better form of bucket. The results considered as absolute measures of effect, being obtained with a form of bucket which approached nearer to the best forms now in use, than did those of Smeaton, or any other experimenter, were more applicable to modern practice, and therefore he must consider his results, as not without utility.

With regard to the custom of only partially filling the buckets, it must be remarked that buckets of the best forms begin to spill their contents before arriving at the lowest point of the loaded arc; the partial filling could, therefore, only palliate the evil which the circular conduit was designed to remedy. He must, however, contend that a positive disadvantage attended the partial filling. A permanent loss of fall was produced equal to the distance between the centres of gravity of the fall, and of the empty portions of the top bucket at the moment it had passed the sluice; this distance could be but little varied by the fineness of pitch of the bucket, and depended more on the depth of the shrouding. That there was a constant loss of laboring force by a practical diminution of the effective leverage, or a reduction in the "moment" of the loaded arc. That as the wheel revolved, the centre of gravity of the fluid contained in each bucket, as it approached the lower portion of the loaded arc, was transferred to a greater distance from the centre of motion even before the contents commenced spilling; but the angular motion of the centre of gravity of any one bucket was at first that due to its distance from the centre of motion of the wheel, or to its radius; and as the radius increased, a greater angular velocity would be acquired by the water which had changed its position on approaching the lower point of the wheel; but this increased velocity was given at the expense of the power of the wheel, and hence a partially filled bucket would, he contended, be always attended with a loss of laboring force. To the last objection, a full bucket was not liable.

From all these reasons, he felt justified in concluding, that the use of the circular conduit was more advantageous than the practice of partially filling the buckets.

With respect to the shuttle delivering the water over the top, where the head of water and the fall were constant, no advantage could be obtained by the use of a wheel greater in diameter than the total descent; it was assumed that this form of shuttle would be used in order always to deliver the water as high as possible upon the periphery of the wheel; but the question was, "If the head be variable, what

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should be the diameter of the wheel to secure the best effect?" The paper showed that a wheel whose diameter was equal to the total descent, when the head was a maximum, did not always give the greatest average laboring force. The question was therefore independent of the sort of shuttle used; it assumed the power of always admitting the water upon the wheel at the highest point of the total descent, and sought to establish the best relation between the diameter of the wheel and the whole descent when the head alone was variable, according to given conditions. The results of this part of the investigation, therefore, while they admitted the full value of Mr. Rennie's shuttle, went further, and pointed out the limits of its useful application.

He was fully aware of the prejudice which existed against the circular conduit, and once participated in it; but his attention had been forcibly drawn to it in his practice, and having used them very beneficially upon wheels of 40, 50, and 60 horses' power, which he had constructed for mining purposes, he wished to draw the attention of the profession to the consideration of their practical merits when adapted to good wheels. Civ. Eng. & Arch. Journ.

Experiments and Observations on Möser's Discovery, proving the Effect is neither due to Light nor Heat. By Horatio Prater.

It is proposed now to demonstrate, that the radiation discovered by Möser is not invisible light, as he supposes, nor heat, as has since been supposed. For, first, where is the evidence that bodies absorb light? Some few, certainly, have been shown so to do; but surely not the metals, &c. &c., which exhibit the greatest facility in receiving and giving the impressions discovered by Möser. It seems, *à priori*, more probable that the radiation in question should consist of heat (which we know exists in all matters) than of light. Accordingly, Mr. Hunt has written an elaborate paper in favor of the supposition that such radiation consists of heat. In the course of this essay, however, it will appear, that neither of these suppositions is correct.

1. *With regard to the nature of the substances that produce spectra.*—Every substance I have tried has produced its spectrum when left on a polished copper plate. Coins, whether of gold, silver, or copper, platinum, nickel, brass, pieces of glass, wafers (red, blue, or white), peppermint or rose drops, whalebone, talc, gum, a horsehair ring, lava from Vesuvius, Indian rubber (but slight), and sealing wax. This last, left ten days, gave a whitish grey *permanent** spectrum, clearer than any of the others, though the wax and plate were both kept dry as usual. The impression on a small brass seal

* By a *permanent* spectrum is always meant, in this essay, a spectrum that remains when the substances or coins are removed—not a spectrum which cannot be rubbed off by *gentle* friction, for all the above *permanent* spectra are yet soon effaced by friction.

(a P) was very obvious when the plate was breathed on. The seal had been left ten days.*

2. *Effects of Dissimilar Metals.*—It has been asserted, that when a gold or silver coin is placed on a copper plate, the effect is greater than when a copper coin, &c. is placed on the same metal. When heat is used, this position is true, as will be shown hereafter; but when the plates and coins are both kept cold, (exposed to external air, for instance, in March,) a farthing, on two different occasions, in an hour, left as good a spectral image as a sovereign,—I thought, a better one.

It was, however, remarkable, when a heat of 160° was applied to this plate, that the spectrum of the copper soon became invisible, while that of the gold was apparently not at all diminished. This experiment was repeated twice with the same result. I likewise found that, though the spectrum of the copper was to appearance, *at first*, as good as that of gold or silver, yet that it began to disappear much sooner, after a few breathings on the plate, than did the spectrum produced by gold or silver. *On the whole*, therefore, it seems right to admit that the effect is greater when dissimilar metals are used.

3. *Effect of Unequal Heat on the Plate and Coins.*—It has also been asserted, that when the copper coin is heated, and the metal plate of copper kept very cool, that the effect is increased. I have, however, not been able to satisfy myself of the truth of this statement. A penny and a farthing, heated to between 130° and 160°, and laid on a cold copper plate half an hour, did not appear to leave even so good a spectrum as two of the same coins left to cool for half an hour outside the window, by the side of the plate itself, before being placed on the plate. All the coins were placed on the plate at the same time, and left the same time. Neither could I perceive any difference when one sovereign was heated and the other not, both being placed on the same copper plate.

4. *Effect of Heat Generally.*—In order to ascertain whether heat hastens the impression, the following experiments were made:—1. A bright half-sovereign, a bright half-penny, and a dull one, were heated to about 150° on polished copper plate. The half sovereign left a *permanent* impression; and both the halfpence left spectra visible only by breathing. It was obvious from this experiment and others, that heat increases the effect where *contact is permitted*,† since

* It left a permanent spectrum of its *margin*. Coins left a similar time do the same; *the part where they have remained retaining its polish*. The permanent spectrum then, in such cases, plainly depends on the substances preserving the plate from oxidation by contact or proximity. I add proximity, because a half-crown or penny resting on a fourpenny piece, placed on the plate, likewise leaves its *permanent* spectrum. The free circulation of the air is impeded here in consequence of the extreme proximity, just as it is by actual contact. Hence the oxidation being less in all such cases than in the parts external to the coins, we have of necessity the permanent spectra.

† Although the mark is permanent in such cases, still it very easily rubs off, even when gold has remained five hours on heated copper plates; and no spectral figure is left when the part is breathed on, after the plate has been well rubbed. As this is the case, such permanent mark is not to be considered as a *different* effect, but only as a *higher degree* of the same effect as that caused by mere imposition without heat. I found all the things mentioned in Section 1. gave a *permanent* spectrum if left eleven days, but only one rendered visible by breathing, being left but a few hours.

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the impression is permanent. Accordingly it was deemed right to try if heat has this effect when the coin is at a distance from the copper plate.

I put a silver fourpenny piece on the plate, and on the fourpenny piece I put a penny. I found that when these remained only twenty-four hours, that no spectral image of the penny was produced; but on remaining forty-eight hours one was apparent. In this last case, the lettering of the fourpenny piece became almost visible when breathed upon, but without this no mark of it was perceptible. The penny piece, however, left its mark without being breathed upon—an annular *bright* mark, which was not rendered more or less distinct by being breathed on. The spectrum of the fourpenny piece was alone brought into view by this.* The place where this had laid was exactly as bright as that covered by the penny. In fact, the copper plate seemed preserved from oxidation by the contact and proximity of these coins. Thus, then, it appeared to require forty-eight hours for a spectrum of the penny piece to be produced—the spectrum of a coin *not in contact.* The same experiment being made at a heat of 160°, no spectrum of the penny appeared after one hour, though the fourpenny piece had left a strong impression.

Ditto, continued for five hours, a spectrum of the penny was *just* visible, and only so when the plate was held in a particular position with regard to light.

A half-crown piece being laid on a half-sovereign, and the same heat continued five hours on the same plate, the half-sovereign left a still better impression than the fourpenny piece † above mentioned, and the half-crown had also made a *permanent* spectrum very visible.

A farthing, which had rested the same time *on* the plate, left no permanent spectrum, but only one slightly visible by breathing. Even when pressed upon by two pence, and left eight hours, it left only a *barely visible* permanent spectrum: so a brass medal. These spectra being rendered far more visible by breathing, could hardly be considered permanent spectra.

These experiments show :—1st. That heat much increases the rapidity of the radiation, *even when the object is not in direct contact;* and 2ndly. That it takes place much more energetically from gold and silver than from copper (a copper plate being used.) They also show that a permanent spectrum is to be considered only as a *higher degree* of that produced or rendered apparent by breathing.

A sovereign, two hours on a very thin lamina of talc, at the above heat, gave no spectrum; talc alone gave its spectrum; nor did a halfpenny, eight hours on the same at the same heat; nor a shilling (new) on a thin piece of glass, the shilling being under a halfpenny.

* However, after six or eight days, *as this began to tarnish*, the spectrum of the fourpenny piece became visible without breathing on it. Yet nothing had been done, except that the plate had been heated to about 150° once or twice for other experiments.

† When the plate was rubbed pretty strongly with chamois leather only, the spectra of the half-sovereign and four-penny piece were soon effaced; while those of the half-crown and penny (not having been in contact with the plate) remained.

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better and more permanent one than the glass.* I should have said the talc was on copper-plate.

The spectrum of the penny, in the experiment lately detailed, is equally visible when the experiment is made on glass; but polished metals seem to show it the best.

When glass is used, there is, after from twenty-four to forty-eight hours, a slight deposition of dust, &c. around the parts which are not covered by the penny, and thus a round mark (permanent spectrum) is visible on removing the penny, even before breathing at all; still on rubbing it off *till nothing is visible,* and breathing on it again, the spectrum of the penny appears, as well as of the fourpenny piece, proving that dust adheres much more strongly than we should have supposed, or perhaps better—leaves its mark behind with greater pertinacity.

That this is the true explanation of the appearance of a spectrum, when the coin is not in direct contact with glass, was to me rendered clear by another experiment, in which a half-crown was left on one sixpence, and a penny on another, on a clean glass plate *covered over with paper, and kept in a closet* for ninety-six hours; yet on examination, neither a permanent spectrum, nor even an evanescent one by breathing, was perceptible either of the half-crown or penny; the sixpences alone had left spectra (which, however, were only visible by breathing), that under the half-crown being the clearest. Yet the penny and half-crown were in the best condition for giving spectra, for the surfaces of both were tarnished, and that of the copper purposely so.

This result induced me to try the same with a copper plate, and I found that when a bright half-crown (having been well boiled in water and then polished) was placed on a fourpenny piece, similarly treated, and left forty-eight hours *covered* in the closet as above, that the half-crown left no spectrum, even evanescent. Neither did a *purposely* tarnished penny placed on another fourpenny piece, and left the same time.

5. *As regards the Distance from the Plate at which Images may be taken.*—A silver fourpenny piece is about the one-twentieth of an inch in thickness, and at this distance we have seen silver, copper, and of course gold, give a spectrum image on a copper plate. But on putting a half-crown and two sixpences and a half-franc piece, making the distance from the plate more than one-tenth of an inch, no spectrum of the half-crown was made, although the experiment was continued for twelve successive days and nights. Neither was any made by removing the half-franc piece (thus making the distance only one-tenth of an inch), and continuing heat at 160° or so for five hours.

A sovereign fixed at three-quarters of an inch, and a small brass medal at somewhat less than half an inch, from a polished copper

* A sovereign on a silver four-penny piece two hours, gave only a very feeble permanent spectrum; the silver leaving, of course, a well marked spectrum.

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in a little closed deal box, gave not the least vestiges of spectra; neither did a fourpenny piece left at one-fifth of an inch, nor a card plate (engraved) left the one-tenth of an inch, for eleven days. The copper plate had remained *perfectly polished* in both experiments; and this is worthy of remark, as showing that in *confined* air copper does not oxidate perceptibly. Another plate left in the *same* room was completely tarnished in five or six days.

A fourpenny piece, about the one-twentieth of an inch, under a silver plate for eleven days, gave scarcely a perceptible spectrum; though a farthing, on which the plate *had rested*, gave a good spectrum, but not a *permanent* one, (*i. e.* breathing was required to show it.)

A fourpenny piece is about the one-twentieth of an inch in thickness, and this seems the greatest distance an image can be taken by the above plan. But even at this distance I have not succeeded, if the half-crown laid on the fourpenny piece is *perfectly* polished, and *all external dust, &c., carefully excluded* by the box just mentioned—(see Sec. 8, on the comparative polish of metals).

Lond. Athenæum.

(To be continued.)

Preparation of Bicarbonate of Soda. By M. Artus.

According to the author, the property of charcoal to condense gases may be turned to good account in the preparation of bicarbonate of soda.

2 parts of effloresced carbonate of soda are mixed with 1 part freshly heated pulverized charcoal (from soft wood), the mass moistened with some water, and then brought into a high cylinder, and carbonic acid passed into it. This gas is allowed to act for 24 hours, when the mass is taken out, pulverized, some water added to it, and again returned into the cylinder, and carbonic acid passed into it. The same operation is twice repeated, the mass is then taken out of the cylinder and treated with 8 parts of hot water, filtered while hot, and the solution left to crystalize. The bicarbonate of soda formed crystalizes from the solution, while the neutral carbonate remains dissolved in the mother-ley, which is poured off, and may be employed for other purposes. The residuous bicarbonate of soda is then washed with a little cold water, to remove the last traces of any adhering carbonate, and is then dried.

In this manner somewhat more than two-thirds of the quantity of neutral carbonate employed, is obtained of bicarbonate of excellent quality. The charcoal assists greatly in the absorption of the carbonic acid gas, hastening the operation, and at the same time the neutral carbonate of soda becomes of a beautiful white by contact with the charcoal.—*Allgem. Pharmaceutishe Zeitschrift* von Artus, No. I.

Lond. Chem. Gaz.

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AUGUST, 1843.

Civil Engineering.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 28.]

LECTURE XI.

In resuming the subject of the Upper Works of Railways, the Professor said he would enter briefly into the consideration of the strongest form of rail, after explaining those points applicable alike to cast and wrought iron bars. First, a certain breadth was required for the bearing surface of the rail, for the wheel to run upon, and this breadth should be such as not to be likely to produce improper action or grooving, in the tire or tread of the wheel, and, at the same time, not to be increased so as to make the rail needlessly heavy; there must also be a sufficient depth or thickness of that bearing surface, to make it strong enough to withstand abrasion, and render the rail sufficiently stiff, and capable fully of sustaining the action of the driving-wheels of the locomotive engine. Hitherto the established breadth seemed to have been about two and a half inches on the top web, or button, and Mr. Vignoles thought, from experience, that that breadth should be considered the *minimum;* however, the strength of this bearing part of the rail, being as the breadth and square of the depth, a greater breadth than absolutely necessary to prevent the tire of the wheels being grooved, would add to the weight of the rail, without increasing the strength more than in the direct ratio of the breadth, whilst the same quantity of material, disposed in terms of the depth, increases the strength in the duplicate ratio. Considering the great increase of

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weight in the locomotive engine of late years, and the continued wear and tear on the rail, from the action of the driving-wheels, and looking to the state of the iron of the upper works of those railways which have not very heavy bearing surfaces, it would seem that, while two and a half inches is a *minimum* of breadth, the chief attention is now required to the proper depth, to resist abrasion and exfoliation which takes place, especially if the iron is not perfectly well rolled. Railway bars are compounded of fagotted iron, and if the pieces are not properly welded the bearing edge is broken down, and peels off; but, supposing the iron good, and the manufacture perfect, the heavy effects of the engine must be provided against, and experience shows that an inch and a half is not too much for the depth of the top web, or bearing part of the rail, and two and a half inches being the breadth, then three and three-quarters—or, say four square inches—should constitute the sectional area of the part that is exposed in receiving the direct action of the driving-wheels; this is the section actually requisite, and the greatest additional strength being to be obtained by increasing the depth, if possible, this is the point to be attended to. It thus appears that a weight of 36 lbs. per yard is required to sustain the engine, and all beyond will belong to the mode of attaching the rail to the support below.

In treating of the wear and tear of rails, Mr. Nicholas Wood has given some curious and interesting results of experience; but the weight of the locomotive engines used is stated to have been only 10 tons, and of this the weight on the driving-wheels would probably not exceed six or seven tons. The result of a variety of experiments on the malleable iron rails of the Stockton and Darlington Railway, gave one-tenth of a pound per yard as the absolute amount of fair abrasion; some statements, however, made it much higher, being one-sixth of a pound. On the Killingworth Colliery, it was one-eighth of a pound. On the Liverpool and Manchester Railway, some years ago, three rails were taken up, carefully cleaned and weighed, relaid, and taken up again at the end of one, and again at the end of two years: the wear was found constant, and about one-tenth of a pound per yard per annum. If we were to take this to be the true wear, and suppose it to arise wholly on the upper surface of the rail, the result would be but the 84th part of an inch in depth, and it might be supposed to take 100 years to wear away a rail from mere abrasion. But later experience shows that the increased weight of engines acts very destructively on rails whose upper webs are not sufficiently strong, and of the best manufacture. We may take 10 tons as the present average weight on the driving-wheels of a locomotive engine; and, if this is to be effectually provided for, the button, or bearing part of the rail, must not be less than 40 lbs. to the yard. Now the form of the remaining part of the rail will depend upon the manner in which it is to be fastened down to the support below, either by being fixed in a chair, which is itself to be again fastened to something else, or by being screwed down, as the rails on the Great Western, Croydon, and the new part of the Greenwich Railway; or, finally, secured in the simple manner described in the last lecture. A comparatively

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very small addition to the theoretical form of rail to be sustained in a chair, gives a section which has the advantage of being capable of being turned in either direction, or vertical position, and hence the top and bottom of the rails have, of late, as previously stated, been made equal and similar, connected by a neck of proportionate dimensions. With the present heavy rails, of nearly 80 lbs. to the yard, the average weight of the chairs, including the joint chairs, may be taken at 20 lbs. per yard, reducing the intervals of support to that constant distance. Thus, we have an aggregate of nearly 100 lbs. weight of iron per yard of each single rail. If, then, we could in any way get rid of the extra weight required to fasten the rail into the chair, and dispense with the chair altogether, it seemed to Mr. Vignoles to be desirable to do so, provided the object in view was equally well attained; and he contended that such would be the case with a 50 lbs. rail attached, in the mode before described, to a longitudinal bearing of timber; for the whole strength of the upper or bearing part would be retained, that being as the breadth and the square of the depth; thus, with a weight of iron just one-half, would be equally efficacious, and it only remained to compare the supports in either case. Now, as stone blocks seemed to be discarded by universal consent, the question of the supports below is narrowed to that of *transverse* or of *longitudinal* wood sleepers. Sufficient experience had been obtained to warrant the conclusion that, for the purposes of this argument, the cost of fastening and of laying the rails, ballasting, drains, &c., taken as a whole, were nearly the same for both systems, and it only remained to contrast the quantities of timber, and, always considering a locomotive line to be the one to be made, it may be stated that this cubing was about double for the longitudinal system to that in the transverse method of laying the sleepers. In short, looking at first cost only, there was a saving of 100 lbs. of iron, and an increase of two cubic feet of timber in each yard of single trackway of the former over the latter mode, so that strictly the longitudinal system was the cheapest; but to avoid minor objections, let the cost of each be taken to be the same, which was giving a decided concession in favor of the transverse system. But this was a very narrow view to take of the question, which wholly omitted the economical results from diminished wear and tear of the engines, of the railway, and of the carriages, as had been most especially exemplified on the Dublin and Kingstown Railway, where the massy granite blocks originally laid down had been all replaced by longitudinal sleepers, and though the old light 45 lb. rails and 15 lb. chairs were retained, the diminution of the annual maintenance was most remarkable, though there was not a railway in the United Kingdom were so many passengers were carried daily throughout the year.

The expense of keeping up the double way, now that the system of longitudinal timbers has been quite carried out, is less than one-third of the corresponding expense per mile per annum of maintaining the London and Birmingham Railway. Mr. Vignoles then read a variety of tabular results of the cost of the three various systems, going through all the details, and pointing out the exact measures

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and quantities, and stating the actual expenditure on the upper works of various lines of railway. The result seemed, that for a double line of railway—upper works, properly laid after the bed of the road was duly prepared, including all the items under that head, which were enumerated in a former lecture, and calculating, for the present heavy and powerful locomotive engine, that no less a sum than £5000, and, in most cases, £6000, per mile was necessary, and that, in many instances, it had reached nearly £7000—the market price of iron and timber, also the quality of the latter, the greater or less facility of obtaining materials for ballast, &c., affecting the amount, and these large sums were independent of the earthwork, masonry, land, fencing, management, stations, carrying establishment, &c. Mr. Vignoles also gave a number of drawings and diagrams contrasting the three systems, and exhibiting, in a very explanatory manner, the modes of laying and fastening. He also exhibited the rail, chair and fastenings, for the transverse method, with all the recent improvements introduced by Mr. Cubitt, on the South-Eastern Railway, and as manufactured by Messrs. May, of Ipswich, and then produced the rail with the dove-tailed slot, and the mode of attachment to longitudinal half baulks of timber, repeatedly alluded to in this and the preceding lecture, observing forcibly, that, if the same effective results were obtainable by the latter simple method as by the former complicated one, it was not only to be preferred in this kingdom, but was peculiarly eligible for such countries as Russia, Poland, Germany, in general, France and America, where wood is usually in great abundance, and where iron is comparatively scarce, especially in the form required for railway bars, and, of course, the prices became in proportion. Mr. Vignoles quoted largely from the works and reports of Tredgold, Barlow, and Lecount, and stated a number of mathematical and empirical rules laid down by those authors, which, he stated, were chiefly relating to rails supported at intervals, but, though he felt it right to lay them before the class, he considered that farther experiments and investigations were requisite, and particularly in reference to the perfect combination in one support of the iron and timber in the longitudinal system, as explained and advocated by him, of which the Professor insisted, the great advantage and peculiarity was that of obtaining a perfect fastening, independent of the fibre of the wood, or the tenacity of the screws or bolts therein, and of obviating the hitherto well-founded objections to the mode of attaching rails having a continuous bearing, which had not been able to prevent a vertical play of the iron on the timber.

SECOND COURSE—LECTURE XII.—RAILWAY ESTIMATES.

This lecture had reference to the consideration of estimates, as applied to railways—that is, to ascertain lineal dimensions, superficies, and cubic contents, and affixing the proper rateable prices, to work out the monied results. The Professor said, that, probably, the most ready way to give a general idea on this subject would be to go briefly over the several heads to be considered in framing an estimate. It was assumed that proper plans and sections of the work had been

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furnished on a much larger scale, and with vastly more attention to accuracy and detail, than had often hitherto been the case, particularly for Parliamentary estimates, observing, that erroneous data and calculations could not but result from a neglect of this rule: and, he stated, that, although many of the standing orders of Parliament were annoying in some respects, yet the principle on which they were framed, went to compel a compliance with forms, in doing which, greater previous investigation and accuracy of plans and sections, became absolutely indispensable.

The *quantity of land* required formed naturally the first item of an estimate. It was but seldom, indeed, that the very small economy of taking land for one line of railway only was adopted. To a given breadth, therefore, for a double line—say, from eight to ten yards—must be added the necessary allowance for fencing and ditching—say, three yards on each side—making a constant breadth of fourteen to sixteen yards of land throughout, independent of the necessary slopes in excavations and embankments; the additional quantity of these, depends, of course, on the depth of the cutting, or height of the bank, in the various places, and on the ratio of the slopes of the earthwork. Suppose, in a cutting or banking of ten feet, this ratio to be one horizontal to one perpendicular, then, such slopes of one to one require ten feet additional breadth of land on each side—together, twenty feet—viz., twice the depth or height to be added as a further breadth, beyond the constant one for the railway and fencing. In like manner, for slopes of one and a half, two, two and a half, or three to one respectively, multiply the varying depths or heights of cutting or embanking by three, four, five or six, as the case may be, for the necessarily augmented breadth of land due to the slopes, along their several extents; and thus, from the lengths measured, and the heights figured, on the section, the varying quantities of land are obtained, multiplying length by breadth, and reducing the areas to acres and parts for agricultural districts, and to square yards for land in towns and their immediate vicinities. For the prices to be assigned to these superficial quantities, the engineer must depend on the land valuer, who is also to judge of the amount of contingent damages. On an average, the actual quantity of land for a double line of railway, including the slopes of earthwork, may be taken at ten acres to the mile, but the precise areas must be ascertained in detail in the way explained. The cost of land for many of the leading lines of railway had been as much as £5000 per mile for the whole of their length. The cost of land for lines at a greater distance from the metropolis was less—still, from the numerous contingent after-charges, in respect of land, the sums were large, and had often far exceeded the original estimates.

The *fencing of the land* comes within the province of the engineer, though it is sometimes comprised in the item of land. The mode of fencing must always be regulated upon the custom and materials of the country. Drystone walls, earth mounds with furze hedges, posts

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and rails, quickset hedges, and broad-side ditches or drains, are the principal kinds of fencing through agricultural lands; walls of brick or masonry, set in mortar, are generally called for through towns or building land. The several lengths of each of these are ascertained from the plans; the prices are obtained in the localities. Including farm-gates, the cost of fencing varies from 1*s*. 6*d*. to 3*s*. per yard lineal in the country. In the vicinity of towns, for stations, &c., the price will vary from 5*s*. up to 10*s*. per yard, according to circumstances, which it must be the business of the engineer to ascertain.

The third item is usually that of *Earthwork*—that is, to reduce the undulating natural surface of the ground to the railway level or gradient, by cutting through hills, and filling across valleys. Mr. Vignoles having, in the first course, entered at large into the consideration of earthwork, thought it unnecessary to say much here. The price of the earthwork depends abstractedly on the average work that an able-bodied man can perform in a day, in various soils—this it should be the study of the engineer to determine. The mere price to the workman, for getting and filling, may be taken at from 2*d*. to 5*d*. per cubic yard, for the various kinds of sands, gravels, or clays; and from 6*d*. to 2*s*. for harder materials, rocks, &c., but, in addition, various other matters are to be provided—barrows, planks, wagons, temporary railways, &c.—the present modern practice in moving large quantities of earth is vastly different to what it was in this country thirty years ago, or to what it still is on the continent, more particularly in the greater distance to which the material is carried; these several distances between the excavations and the points of depositing them, either into embankment or to spoil, must be ascertained from the longitudinal section, and a careful examination on the ground—these distances are technically called *the lead*; for distances under a quarter of a mile, the prices are higher, in proportion, than for longer distances. Taking the average description of soils, and the average distances, 1*s*. per cubic yard may be taken as a covering first estimate, upon the whole number of cubic yards of excavation or of embankment, whichever may be the larger quantity shown upon the section. The quantities of earthwork in a railway, on an average per mile throughout the whole distance, might be taken as a characteristic of its cost, so far as mere construction went, independent of carrying establishments, stations, and land, over which items the engineers seldom had control. Mr. Vignoles said it would be very interesting to have an abstract of the quantities and cost of the earthwork, distances carried, &c., on all the railways, and indeed of all other items of the works, as actually executed; they would become valuable precedents for future estimates, particularly if accompanied by explanations of the circumstances under which the operations were carried on. The great haste with which many of the railways were executed, while the late powerful excitement lasted, had added greatly to the cost, by raising the price of labor. Mr. Vignoles stated that he had already given some such abstracts of the railways that had been executed by him, or under his directions, and he was prepared to give more, and he hoped that other engineers would follow his example,

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as it could not but be very satisfactory to the proprietors of the different concerns, as well as a justification to the engineers themselves, and to the directors, that they could go into the minutest detail of expenditure. The Professor then gave abstracts, in round numbers, of the quantities of earthwork on many of the principal lines of railway, as well as could be ascertained from the sections. He mentioned the North Union Railway, twenty-one miles long, with 125,000 cubic yards of earthwork per mile, at an average cost of 10¾*d.* per yard, including all extras and contingencies. The Midland Counties, 57¾ miles, with 100,000 cubic yards of earth per mile, at an average cost of 13*d.* per yard, including slips and all charges, the soils nearly the same in each, and the average lead nearly alike—viz., one mile—attributing the difference to the great haste and great demand for labor in the latter. The mean of these would be now a fair estimate.

Having estimated for the cost of obtaining the artificial bed of the railway, the next item would be the *Bridging and Masonry*—that is, to restore the previously existing communications of roads, canals, or other railways, the passage of rivers, watercourses, &c. &c., by viaducts, aqueducts, ordinary bridges, culverts, drains, &c., and often by heavy retaining and breast walls. Under this head came the bridges of brick, timber, or iron;—in very marshy countries, where the foundations are likely to be bad, and the drainings liable to be affected, timber may be resorted to, and used in the shape of piling, with cross beams to sustain the rails across the openings, avoiding thus the cost of arches, abutments, and wing walls. The ascertainment of the several superficial or cubic quantities in each of these different constructions, is a matter of simple mensuration from the working drawings. The attachment of prices to these, in all their various details, with sufficient accuracy, depends on the mature judgment and experience of the engineer; and it is by a long course of careful study and observation that the young student, in his employer's office, and on his works, can alone hope to acquire this knowledge. It was but too common, in making estimates, to fall short in this item, particularly in the number of occupation bridges, which owing to the complicated holdings, improvements, &c., had to be provided for to a vexations extent, or bought off. The masonry is generally in proportion to the earthwork, and in many cases has happened to be of nearly the same amount of cost. The average number of bridges on a main line of railway might be taken at five for two miles. Diversions and embanked approaches of roads, gravelling or metalling the new surfaces, and the contingent operations, should be separately calculated. They are included under the head of fencing, of earthwork, or of bridging, or kept as a distinct item, according to the practice of the engineer, but they form a large sum, varying from 100*l.* to 500*l.* per mile, according to circumstances, and, in preliminary estimates, are too often omitted, or are put into that refuge for all deficient items—contingencies.

The item of *Upper-Works* in general, or *permanent way*, had been gone into so fully in the recent lectures, that it was not necessary here to do more than mention it, as forming a leading point in considering

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estimates. It is usual to add 10 per cent. upon all the items of the estimate, properly belonging to the engineer. Besides these were the preliminary expenses of surveys and Act of Parliament. The management, including cost of conveying, &c., and all salaries and expenses of direction, office, engineers, solicitors, &c. &c. Then came the expenditures on the stations, engines, carriages, repairing and building shops, fittings, and all the carrying establishment necessary for passengers, also for goods and for ware houses, wharfs, and other accommodation. It was in them the heavy extra expenditure of railway capital mostly went, and which, in the early stages of the railway system, could not be properly judged of. By way of summary, Mr. Vignoles said he would give, in his next lecture, the actual cost of one or two lines of railway which had come under his direction, and which might be useful by way of reference in making out estimates on other occasions, though the construction and working of railways must be regulated on much more economical principles than had hitherto been the case, or no more of them would be undertaken.

(To be continued.)

On Bridges.

At the ordinary general meeting of the Royal Institute of British Architects, held on Monday evening, the 15th May last, Professor Hosking illustrated and explained his proposal to improve the design of arched bridges, by the introduction of a transverse arch, groined into the longitudinal arch, or series of arches; and showed the effect of this and other suggestions he has made for the improvement of bridges, in a design for remodelling Westminster Bridge.

Mr. Hosking began by stating that the closely attentive consideration of the subject of bridge designing and building, rendered necessary by his engagement with Mr. Weale,, to supply a practicable treatise for the extensive work on the Theory and Practice of Bridges, now lately published, gave rise to some suggestions of improvements in design and construction, which he believes to be novel, and knows (as far as he is concerned) to be original.

His object, on that occasion, was to explain and illustrate the more important suggestions he had made, that they might not be misunderstood, and might be more extensively known than they were likely to become whilst they rested within the covers of a professional library book.

On a former occasion, in that room, he had made some remarks upon the subject of bridge building generally, and had urged that the piers of bridges were built of much greater substance in thickness, than was necessary for either safety or agreeable effect; that they might, therefore, be greatly reduced in bulk, both for economy and for their effect upon the water way, and without diminishing their efficiency. It had been objected to him, however, at that time by some of the members—with the too common fault of architects, who would sacrifice use to effect, instead of compelling the useful to be effective—that his proposal tended to destroy the due proportion in

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appearance of the pier to the opening. The eye that had been accustomed to the bridges upon the Tiber, at Rome, of which the piers are rarely less than one-third the span of the larger of the two arches resting upon them respectively, would be offended by the absence of that proportion of solid to void in London and Waterloo Bridges, in which the same relation is but one-sixth; whilst the eye accustomed to the bridges upon the Thames, at London, would condemn the bridges at Staines, and the bridges of Jena and Neuilly, on the Seine, of which the piers are but one-eighth, one-ninth, and one-tenth of the span of the arches resting upon them. Nor have we yet reached the limit to which the diminution of proportion may be reduced with safety and good effect. Further to justify such further reduction, was one of the ends to be answered by the arrangement he was then to explain, which has the effect of reducing also the weight to be sustained by the piers of an arched bridge. The idea had occurred to him, and he had matured it so far as to be able to speak of it with confidence on the former occasion alluded to above, but as he was then unprepared with illustrative diagrams, he had thought it better to withhold it for the time.

The proposed improvement consists in groining a bridge arch, or in carrying a groined transverse arch through the length of a series of arches; and the advantages derivable from this plan consist in lessening the weight of the bridging constructions; in reducing the thrust upon the abutments, and, consequently confirming the stability of both arches and abutments; in diminishing the liability of the bridge constructions to vibrate under the action of pulsating or of rolling bodies; and, generally, in greatly reducing the cost of construction.

The weight is obviously lessened by the difference between the massive haunches of the main vaults, and of the requisite backing to them through the extent of the transverse arch, and the comparatively light inner transverse arch, which being of slight span, may be of stones of much less depth than the main vaults require; the thrust of the main vaults is clearly dissipated throughout so much of the width of the bridge as the inner transverse arch occupies, and so that if the latter occupy the proportion of the width that might be given to it, the abutments of the bridge may be reduced to mere wing walls; the vibrations arising from the traffic upon the bridge are checked at the groin points as at nodal points in a vibrating cord—and the groins lie directly under the carriage road where alone any action that could be felt in a heavy mass of masonry can arise;—and the cost of construction is reduced by the reduction in quantity of the materials in the piers and in the vaults—by the reduction of labor required for the softer stone available for the inner transverse arch, and by the lighter centering sufficient for the same.

He had endeavored to illustrate his suggestions by applying what he proposed upon a compartment of London Bridge, as a familiar instance, but without any idea of reflecting upon the existing condition of that magnificent work. [Here Mr. Hosking explained the

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diagrams, which were merely enlargements of the plate which illustrate the same subject in the Treatise on Bridges.]

The only indication of such an arrangement as that he suggested, in any existing work with which he was acquainted, is in Perronet's Bridge of St. Maxence, where low arches are introduced over the divided parts of the piers transversely of the bridge, to take the springings of the great longitudinal arches, but these have neither the intention nor the effect of what is proposed, and are a source of weakness and expense, rather than of economy and endurance. [The diagrams which illustrated this, showed that the transverse arch was low and flat, instead of rising to the full height of the great longitudinal arches, and must, therefore, exert a great thrust upon the divided portions of the piers which abut it; and as the vaults spring upon the backs of these transverse arches, there is no relief either in thrust or weight by groining.]

He was well aware that the suggestion he had made was exposed to controversy, upon the presumption that the transverse arch may not have sufficient abutment within the length of a pier, transversely of the bridge, and as the theory of the groined arch has not been satisfactorily determined, if, indeed, it has been really investigated, he must claim to refer to experience, and assert upon example, that the inner arch, as he had drawn it in the diagram, was superfluously abutted. Under any circumstances, indeed, it can be only a question of greater or less span of the inner transverse arch, with reference to the abutments afforded to it by the springings of the outer and greater longitudinal arch to which it is groined, since there can be no question but that if the abutments are sufficient to restrain the arch, the opertion may be safely carried out. In the example, the transverse inner arch occupies but half the length of the pier, leaving the minimum abutment equal to half the span of the arch, with the means of increasing it to almost any extent, by raising buttresses upon the heads of the cutwaters.

Numberless instances exist of arches of far less rise in proportion to their span, than the present example shows, abutted only by the piers on which they rest, or rather by a substance upon their haunches extending only to the thickness of their piers; the piers being far less in proportion to the span, than in the example, whilst the proportion of abutment to span should increase, as that of rise to span diminishes. Trajan's Bridge over the Tagus, at Alcantara, the Pons Palatinus, or Ponte Rotto, upon the Tiber, at Rome, the ruins of Augustus' Bridge, at Narni, are cases in point, and every cathedral chapter-house in England, in the pointed style of architecture, and every arcaded cloister, furnishes another instance to the same effect.

Another question may arise as to the sufficiency of the area of the bearing surface upon the piers at the springing of the arches, for very much less is allowed, than it has been usual to give in such cases.

Perronet calculated upon experiments, that the stone of which his Neuilly Bridge was built, is capable of sustaining twelve times the weight imposed upon it in the piers of that bridge. The area of the

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bearing surface of the piers of Neuilly Bridge, is about one-tenth of the area covered by the two half arches resting upon the piers respectively. In the supposed case, the weight of the superstructure, as compared with Perronet's, is diminished by the introduction of the perforation in the arches, longitudinally of the bridge, and the stone of which London Bridge is built, being stronger than the stone used by Perronet, in a much greater degree than the difference of their specific gravities would indicate; the substance of the arches built of the stronger stone, may be relatively reduced. These circumstances operate to such an extent, that the weight of the superstructure is reduced, as compared with Perronet's work, nearly, if not quite, one-fourth; and as twelve times the sufficient strength is, besides, very much more than enough for the extremest contingencies, it is not too much to assume that the area of bearing surface of the arches at the springings, or on the piers, may be taken at one-fifteenth the area covered by the two half-arches. In justification of this assumption, it may be added that, without the same reason for it, but with flatter arches, certainly, than at Neuilly, Perronet made the area of the bearing surface upon the piers at the springings of the arches in the Bridge of St. Maxence, and with the same stone of Saillancourt, less than one-seventeenth the area in horizontal section of the space, covered by two half arches.

But the granite used in London Bridge, is of considerably more than twice the strength of the Saillancourt freestone in the bridges of Neuilly and St. Maxence, and upon which Perronet's experiments were made; and, therefore, the area of the bearing surface of the arches at the springings, may be one-thirtieth the area in horizontal section of the space covered by the two half arches resting upon any pier.

This is the proportion allowed in the case supposed, and the area of bearing face is upon the calculations regarding Neuilly Bridge, and having reference to the different powers of resistance of the two kinds of stone, more than enough for ten times the load it would be called upon to bear. Having reference, however, to other instances of the powers of stone to resist crushing pressure in the central pillars of some of the cathedral chapter-houses, it may be safely concluded that experiments upon small pieces of stone give results much within the strength of the material in the block; so that having counteracted the tendency of the traffic upon a bridge, to induce vibration in the structure by the introduction of the deep transverse arch, groined to the flat longitudinal arches; it is believed that the bearing surface at the springings of the arches, and, consequently, the piers under them, might be reduced, not merely with perfect safety, but with great advantage, very much beyond what he had now endeavored to justify, in the example before the meeting.

Mr. Hosking then proceeded to explain the advantages of corbelling out the parapets on bridges, according to the method he has proposed in his Treatise on Bridges; and read some passages in explanation of them, from that work; and showed, by diagrams, the manner in which the work might be composed constructively, and, as to decora-

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tion, either plainly corbelled, or enriched faces to the parapet. He then resumed his remarks, and stated that in closing his observations upon the design and arrangement of bridges, he could not avoid noticing a pressing instance of an important work, within the personal knowledge of all who live in, or have ever visited London, rendered by circumstances which have grown up around it, altogether unfit, both in its design and arrangement, for the position it occupies. In September last, he wrote, in the *Treatise on Bridges*, as follows:—

"It is difficult to close a *Treatise on Bridge Architecture*, without remarking the increased unfitness of the present superstructure of Westminster Bridge. The arches spring at a level very little above that of low water, where the tide rises and falls from 15 to 18 feet, so that the water-way is nearly 50 feet, or about one-sixteenth less at the height of ordinary spring tides, than at the level of low water in the river. The arches contract the way for navigation much more than it is at all necessary they should, even upon the present piers, and there is more than twice the height from the soffits of the arches to the level of the roadway, than there need be; the parapets are alike offensive, by their great height from the roadway, and by their ugliness in detail, and injurious by the drafts induced by the perforations of the balustrades; and the solid counterfort buttresses over the cutwaters, and their inclosed and cupolated heads, add needlessly to the weight upon the piers. The bridge is unfortunately near to the magnificent buildings of the Houses of Parliament, and its great height renders this proximity more injurious than it might otherwise be. In all probability some abatement will be made of the height of the bridge in the process of the works now (1842) in hand for securing the pier, and, doubtlessly, the same good sense which opened a view of the river from Blackfriars' Bridge, will open the magnificent prospect Westminster Bridge can command, by substituting parapets, which shall be truly so, for the perforated walls which now hedge in the road-way; but the arches will still continue to render the navigable water-way narrower and more inconvenient than even the multiplicity and thickness of the piers, or the condition of the work, impose. The character of the work, too, will still remain inconsistent with its position at Westminster. It ought, therefore, to be completely remodelled. As the piers are now in process of being repaired and secured, and so as to be free from any danger, founding new piers is out of the question, and the piers cannot be reduced in number without imposing additional weight on those which may be left; a condition which the original defective founding, and the badness of the original structure, forbid. The whole of the superstructure might be removed, however, and the piers being carried up from the level of the present springing to that of high water, of the substance which the cutwaters now show within that range, flat pointed arches might be sprung at that level, and the whole superstructure re-constructed in accordance with the prevailing style of the Abbey, Hall, and Palace of Westminster. The longitudinal central groining herein before proposed, might well be adopted with excellent effect, lightening the upper works, relieving the thrust of the arches, and

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new. The widening of the water-way, by the removal of the springings of the arches out of the water, would allow characteristic abutments to occupy the space now taken up by the two first arches of the series of thirteen, as well as the site of the two small land arches, without affecting the current, injuriously; and as the flat, pointed arch would give much more freedom to the navigation than the semi-circular arch affords, independently of the increased lateral space in every bay, the vertical head-way might be taken at an average of that now afforded by the central group. Moreover, the increased space at the approaches obtained by obliterating the useless land arches, would allow the accesses to the bridge from the low ground on either side to be greatly improved, and the ascent eased by dividing them to the right and left over the abutments, and so to distribute the rise over a longer space, and give the means of dividing the going and coming traffic."

These observations, continued Mr. Hosking, coincide in a very remarkable degree, with those upon the same bridge, in the report lately presented by Mr. Barry, to the Commission on the Fine Arts, in connexion with the House of Parliament. It was true that his suggestions stood alone in the particulars in which it was almost certain they would be peculiar; as it regards the introduction of the inner transverse arch groined to the main vaults; the increase of the span of the arches upon the same piers, (for he did not understand Mr. Barry's report to contemplate that) and in widening, winding and dividing the approaches for the double purpose of use and delight. It was quite clear, however, that as his remarks were written in September of last year, and—with the wood-cut illustration of the subject which appears with the text—printed in October, though not published until February of this year, he might claim some credit for having taken the same view of the subject that had already, he doubted not, presented itself to the mind of their eminent contemporary, whilst it might be held to strengthen, in some degree, the view they had both taken, that it had occurred to both Mr. Barry and himself, without communication or knowledge, indeed, of each other's doings, to support it by the same train of argument.

Civ. Eng. & Arch. Journ.

Gen. Pasley *on crossing Railways, by common roads at the same level.*

Railway Department, Board of Trade, 17th March, 1843.

My Lord—In obedience to your Lordship's orders, that I should examine the projected Peterborough branch of the London and Birmingham Railway Company, and report whether the unusually numerous level crossings of turnpike, parish, and other roads intersecting it, as well as the single line of rails proposed, will be objectionable on the ground of public safety, in the event of this branch being carried

I carefully examined the whole of the line proposed as far as Peterborough, which occupied two days, because it was necessary for me to cross the Nene continually from one side to the other by a circuitous route, sometimes along the left, and sometimes along the right bank of that river.

Mr. Bidder, the second engineer of the proposed branch, in the absence of Mr. Robert Stephenson, having lent me an ordnance map on which he had traced the whole line in red, and having also supplied me with lithographed plans and sections of the same on a very large scale, that will be submitted to Parliament, I was enabled to trace it on the ground to great advantage; and I consider the line chosen between Blisworth and Peterborough to have been extremely judicious. It will descend the valley of the Nene, occasionally crossing that stream, and never receding from it more than about a mile and a quarter, to cut off the sinuosities of the river, which flows with a moderate descent through a valley varying in width, but nearly level; so that the proposed line will have the advantage of requiring few embankments and cuttings, and of very moderate height or depth, and only one tunnel, of 688 yards in length, in crossing the high ground to the south of Stibbington. Hence the level of the proposed railway will differ so little from that of the natural ground over which it is to pass, that it may be executed at much less expense than other railways in general, provided that the Company who is to form it be allowed to use level crossings for the roads that will be intersected by their line, which are so numerous, that if the bridges over all, or most, of those roads be made a *sine quà non*, it will be a complete veto to the undertaking, because, one of those bridges might cost nearly 7,000*l.*, including not merely the principal arch itself, but the approach to it, whether consisting of earthen embankments or of brick arcades, especially in those parts where the railway may require to be raised five or six feet to guard against the inundations which occur from time to time in the valley of the river Nene.

In order to judge how far level crossings may be dangerous to the public safety, I have repeatedly passed along the Northern and Eastern Railway, from Stratford to Bishop Stortford, which may be considered as a prototype of the Blisworth and Peterborough branch, as it ascends, first, the valley of the river Lee, and then that of the river Stort, in the same manner that the latter will descend the valley of the river Nene; and, in consequence of this advantage, the Northern and Eastern Railway has been completed with very little labor of earthwork, but it abounds in level crossings, there being no less than 19 or 20 in the space of 28 miles, at all of which, except private or occupation roads, gates have been erected shutting across the road, and only opened for passengers when required, at which period they are shut across the railway. This is done by a gatekeeper living in a cottage on the spot. The trains of the Northern and Eastern Railway never slacken their speed in passing those points, unless the gates should be shut across the railway, which are sufficiently con-

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spicuous by day, and rendered so by a red lamp at night, which is a signal to stop. This railway has been opened, though not to the whole of its present extent, for about two years and a half, and no accident has ever occurred at any of its numerous level crossings. The example of this line is, therefore, a sufficient proof that level crossings on a railway are perfectly safe, if steady gatekeepers be employed at all of those turnpike, or other public roads; and the management of the Birmingham Railway is so very perfect, and all the enginemen, policemen, and others in their employment, so competent and correct in the execution of their duty, that I see no danger whatever in allowing them to have as many level crossings as they please in the proposed line between Blisworth and Peterborough, which will not be more numerous in proportion, than on the Northern and Eastern Railway, for the number will be about 28 in 47 miles, of which the greater part are little frequented; whilst at the crossings of the most important public roads, it is proposed to have stations where the trains will stop; indeed, on a review of railway accidents by collisions, there have been much fewer at level crossings than on the regular lines of rails, and the worst of the former occurred when the custom of shutting gates across the railway prevailed as a general rule; the danger of which having become evident, it has since been abolished. In respect to accidents to foot passengers at level crossings, these have not occurred, nor can they ever occur, except through the extreme imprudence, recklessness, or intoxication of individuals.

Upon the whole, I feel it my duty to certify that the proposed level crossings on the Blisworth and Peterborough line are unobjectionable on the ground of public safety, provided that there is a proper gatekeeper stationed at all the crossings of turnpike, parish, or other public roads; and I can see no necessity for slackening the speed of the trains at every such crossing, except for a limited time after the first opening of the proposed branch, which is always prudent in new railways.

I before mentioned that it is proposed to lay down only one line of rails between Blisworth and Peterborough, but the intention is to make the permanent roadway wide enough to admit of a second line of rails hereafter if required. In very short lines, in which the trains may go from one end to the other, and return again without meeting or crossing each other, even if there be a considerable traffic, no chance of collision can occur; but I apprehend that the proposed Peterborough branch will be too long to be worked in this manner, unless the traffic were very small indeed, and, therefore, that the up and down trains will have to cross each other at some central station, where there must be a double line of rails for that purpose. This may be effected without the smallest risk of collision by good arrangements, for which the Directors and officers of the London and Birmingham Railway Company may be trusted, and which are so obvious, that I shall not enter into details. Indeed it appears to me that there is so little difficulty in this matter, that it might be accomplished with perfect safety to the public, even without the electric

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because if any accident should occur to prevent one train from reaching the central or junction station in proper time, the circumstance may be made known at that station, to do away with all suspense; and, if such accident should entirely stop, instead of merely delaying, the train, it may be got into a siding, of which there will, no doubt, be several, and when this is made known by telegraph, the trains moving in the opposite direction may proceed without being stopped also.

After having finished my inspection of the proposed branch from Blisworth to Peterborough, I returned by way of Huntingdon, Cambridge, Chesterford, Newport, Bishop Stortford, in order to view the ground over which it is proposed that the extension of the Northern and Eastern Railway shall eventually pass: and one thing is certain, that, if this extension should ever take place, no passengers from Peterborough, or the vicinity of London, will go by the circuitous route of Blisworth; so that the branch which forms the subject of this letter, will be confined to the traffic of the valley of the Nene, along which it is to pass. I have the honor, &c.,

(Signed) C. W. Pasley, *Major-General*,
Inspector General of Railways.

The Right Hon. the Earl of Ripon, &c. &c. &c.

Railway Magazine.

Preserving Timber.

Payne's Patent for preserving timber from the ravages of the dry rot, insects, &c., is now likely to be brought into extensive operation; the process consists of impregnating timber with a solution of the sulphate of iron, and forms an insoluble chemical preservative, and by the process adopted, impregnates the timber to the very centre; this is effected by placing the timber in large iron tanks with the solutions, and then first exhausting the air, and afterwards readmitting it, and then using a force-pump, with a pressure of 200 lbs. on the square inch, to force the solution into the heart of the wood, which it does very effectively. Iron, as a preservative to timber, has long been known, and it is now, through the ingenious process adopted by Mr. Payne, likely to become very extensively adopted. The Company is now preparing the timber to be used at Claremont, for the royal stables, by command of the government.

Civ. Eng. and Arch. Jour.

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The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 54.)

II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

Having shown the use of cemeteries, we shall next consider the mode in which the ground should be laid out or arranged, with reference to these uses.

The *situation* of cemeteries, as they are at present used, that is, interring several bodies in one grave, and placing coffins in vaults, ought always to be at a distance from human dwellings; but if only one coffin were to be placed in each grave, and that grave never again opened, but the cemetery when filled, used as a public garden, its situation might be regulated solely by convenience; and, in general, the nearer the town, the more desirable it would be, both as a burial-ground and a promenade. Cemeteries, as at present used, ought to be in an elevated and airy situation, open to the north, but with a south aspect, that the surface may be dried by the sun; rather than with a north aspect, where the surface would be moist during the winter months. If the surface be even, it will be more convenient for interments, than if it were irregular, whether by broken ground, rocks, or undulations. It should be as near the great mass of the population for which it is intended, as a due regard to their health will permit, in order to lessen the expense of carriage, and shorten the time of the performance of funerals, and of visits by the living to the tombs of their friends; it ought to be conspicuous at a distance, because, from its buildings and tombs, it will generally be an ornament to the surrounding country, and an impressive memento of our mortality; and the outer boundary ought to be regular and simple, in order that it may be short, and, consequently, less expensive than if it were circuitous.

The *soil*, for reasons which we have already noticed, ought to be dry to the depth of 20 or 30 feet, or capable of being rendered so by underground drains. It ought not to be generally rocky, at least where deep graves are to be dug. As in decomposition, a considerable quantity of moisture (sanies) is exuded, the greatest care ought to be taken not to form a cemetery over a stratum of soil which contains the water used in the neighborhood for drinking. Not to mention numerous instances in London, as noticed in the *Report on the Health of Towns*, there is a churchyard near Kirkaldy, in Fifeshire, with a perpetual spring immediately without the boundary wall, the water of which, passing through a stratum under the graves, is said to be contaminated; and the burial-ground of St. Peter's Church, Brighton,

cannot be used as such, on account of the proximity of the chalky stratum which contains the water that supplies the wells of the lower part of the town.

In situations where, from the flatness of the country or the nature of the soil, there is not an opportunity of draining to a great depth, care ought always to be taken to carry off as much as possible of the surface water by shallow underground drains placed under the roads, and under the gravel walks and green paths which separate the lines of graves. No drains can be made under those parts of the surface in which graves are to be dug, for obvious reasons. Many details of this kind, which need not be entered into, will readily occur to the practical man.

The prejudices of the living, in every country, are in favor of a gravelly, sandy, or chalky soil; and in such soils draining is not required. In strong, clayey soil, like that of most of the London cemeteries, decomposition does not take place for a very long period, the fleshy part of the bodies being changed into adipocere.

The *extent* of a cemetery must, of course, depend on the population for which it is intended; the probable increase or decrease of that population; and whether one, or more than one, interment is to be made in the same grave. The data on which to form the necessary calculations, are, that the average outside dimensions of a grave are 7 ft. by 3 ft. 6 in.; that the average dimensions of a grave, where a number of them are supposed to have grave-stones, are 8 ft. by 4 ft.; and that the average deaths in a healthy population in the country are 2 per cent., and in crowded towns and cities 3 per cent. per annum. Thus, 20 graves will be required per annum for a rural population of 1000, and 200 per annum for a population of 10,000. An acre will give 1361 graves, which will afford a supply for nearly seven years; and three acres will serve for twenty-one years. At this latter period the town will probably have increased on the side next the cemetery, when the additional ground should be taken at a greater distance, and the old ground, when fully occupied, may be sprinkled over with trees, to be eventually used as a place of recreation for the living. The calculations, however, will be considerably different, if we suppose that all the graves are to be without headstones, and, consequently, no longer than is necessary to admit the coffins. For this purpose, the average width of the grave at one end may be 2 ft., and at the other 20 in., and the length 6 ft. Taking the greater width, this will give 12 square feet to each grave, which will give 3630 grave to an acre. These graves in the London cemeteries are dug 15 ft. in depth, and ten coffins of poor persons are deposited in them. The common charge is 25*s.* for each coffin, or at the rate of the enormous sum of 45,375*l.* per acre. In some cemeteries, as many as fifteen coffins are deposited in one grave, the depth in that case being 20 or 25 feet. We could name a cemetery in which forty-five coffins, we are assured, have been deposited in one grave.

The situation, soil, and extent being fixed on, the next consideration is the *boundary fence*, which ought to be such as to insure security from theft, and favor solemnity by excluding the bustle of every-

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day life, while a view of distant scenery is admitted to produce a certain degree of cheerfulness, and dissipate absolute gloom. In an open part of the country, where there are few buildings or public roads, an iron railing may be employed as a ring-fence; but, in a populous neighborhood, a wall 10 or 12 feet high, strengthened by buttresses carried up above the coping, so as to give the wall an achitectural character, may be preferable. The buttresses may be of two kinds: ordinary ones, merely for strengthening the wall, or forming piers to panels of open iron railing; and, in the case of cemeteries not laid out in beds or panels, higher and more massive piers rising conspicuously above the others, at regular distances, to receive stones having cut in them the numbers and letters used as indexes to lines for ascertaining the situations of graves, in the manner which will be hereafter described. The numbers and letters alluded to, are at present in most cemeteries painted on the brickwork, which has a mean temporary appearance; or they are put on stones or labels of cast iron inserted in the soil, and rising only an inch or two above it, which are liable to be disturbed by the moving of the ground. Though we entirely disapprove of this mode of laying out a cemetery, yet, as it is generally practiced, we have thought it right to keep it in view. Where economy is an object, a hedge and sunk wall may be used as a boundary, and the best plant for the hedge is the common holly. There ought to be one main entrance; and, if the situation admits of it, a second entrance, for the admission of workmen, carts, &c., necessary for carrying on the executive part of the cemetery.

In *laying out the interior*, the system of roads and walks, the drainage, the situation of the chapel, or chapels, and the arrangement of the graves, and of the marks which in large cemeteries, as at present laid out, are necessary, at the angles of the squares, require to be taken simultaneously, and also separately, into consideration. There ought to be at least one main road, so as to allow of a hearse having ready access to every part of the grounds; and from this road there ought to be gravel walks into the interior of the compartments formed by the roads, walks, and the boundary wall; and, from these gravel paths, ramifications of narrow grass paths, so as to admit of examining the graves in every part of the grounds, without walking over any of them, and thus insure respect for the dead. We have already observed that all the drains that require to be made must be under these roads, walks, and paths, so as not to interfere with the graves; and the ranges of situations for graves must be determined before the roads, walks, and green alleys are fixed on, otherwise there might be a waste of ground. To be convinced of the bad effects of the neglect of surface drainage in a cemetery, it is only necessary to walk on the grass of that at Kensal Green during winter or spring.

The first point to be attended to, according to the present system, unless the cemetery should be a small one of only an acre or two, is to devise a system for *throwing the interior into imaginary squares or parallelograms,* which shall be indicated by numbers and letters on the boundary fence, and by marks inserted in the ground at their points of intersection. In cemeteries of moderate dimensions, more

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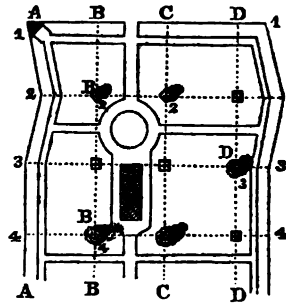
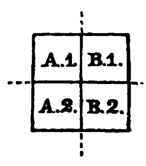
particularly if the form be rectangular, the marks at the intersections of the squares may be dispensed with; these intersections being readily ascertained when it is desired to find out the precise situation of any grave, by stretching lines across the cemetery from the letters and figures on the boundary fence. For example, suppose fig. 1 to represent a cemetery of five acres, with the letters A, B, C, &c., marked at regular distances on the end walls, and figures 1, 2, 3, &c., at the same distances on the side walls; then, by stretching one line from B to B, and another from 2 to 2, &c., the intersections of the strings will give the points B 2, C 2, &c.: but supposing the surface of the cemetery to be very hilly, or that it is thickly studded with tombs or trees, then, as the lines could not be readily stretched so as to give the points B 2, C 2, &c., with perfect accuracy, a stone, or mark of cast iron, is inserted when the cemetery is first laid out, in each of the intersecting points, with the letter and figure on it, as shown in the diagram fig. 1, at B 2, C 2, D 3, &c.

Fig. 1.



At every other point of intersection throughout the cemetery, there is a sunk stone, or iron, inserted, with the letter which stands at the ends of the long lines, and the figure which stands at the ends of the cross lines, as shown on a large scale in fig. 2. Thus in the diagram fig. 1, we should have the squares A 1, B 1, C 1, D 1, &c.; and A 2, B 2, C 2, &c. The use of these squares is to enable the sexton to ascertain and point out, at any future time during the existence of the cemetery, the precise spot where any interment has taken place. For example, required to see the grave of T. W. On turning to the index of the register book of names, T. W. is found to have been interred in the square B 4. Now, on turning to the map book of the cemetery, in which every imaginary square into which the cemetery is parceled out, is laid down on a large scale, the position and dimensions of the grave will be found delineated according to the scale; and then, by taking the dimensions from two of the sides of the square and applying them to the ground, the exact position of the grave is found, even though the grave mound should be obliterated. Now it must be evident that it would be exceedingly inconvenient to have the stone marks fall into positions where buildings were to be erected, or roads or walks to be laid out; and hence the propriety, as we have said above, of determining the position of the intersections of the squares, before any other part of the laying out is proceeded with. This is the more necessary in cases where the intersecting points are to be marked by trees of particular kinds, or by an obelisk, or other monumental stone. By using an obelisk or other pillar with four sides, pointing diagonally to the four squares, as at

Fig. 2.



those buried in each square, if the parties interested thought fit to incur the expense. It is not necessary that all the squares or parallelograms should be of the same size; on the contrary, their dimensions may be varied, so as to suit the ground, the boundary, and all the different circumstances connected with the general arrangement. In some cases the intersections of the squares might be indicated by trees, as shown at B 4, D 3, &c.

It must be confessed, however, that this system of laying out a cemetery into imaginary squares, is a very unsatisfactory one, for the following reasons:—1. It neither admits of a permanent system of surface drainage, nor of grass paths among the graves. 2. From there being no obvious principle of order or arrangement in conformity with which the graves are placed, the general aspect of the interior of the cemetery is confused and unsatisfactory; the graves and tombstones seeming to be put down at random as in common churchyards. 3. A very slight error in mapping the graves may render it difficult, if not impossible, to identify a particular grave, either to point it out to the relations of the deceased; or, when the square is nearly full, for the purpose of avoiding an old grave in digging a new one. Let any one who doubts this, examine the map books in the principal London cemeteries, and ask to see one of the graves indicated in the plan. 4. Unless a head-stone is put to the grave, or some other permanent mark, it is impossible for any person but the sexton to identify it; which circumstance can by no means be rendered satisfactory to the relations of the deceased. 5. No provision is made for paths among these graves, so that, when the squares are nearly full, there will be no mode of getting to any one grave, but by walking over a number of others; which is not only a species of desecration, but, when there are several of the graves having headstones, must be exceedingly inconvenient.

A much better system, in our opinion, is to lay out the ground in what may be called double beds with green paths between, in the manner to be described in a future paragraph, which has an orderly appearance, admits of a permanent system of surface drainage, requires no mapping, and enables the friends of the deceased to recognize the grave they wish to see, without troubling the sexton or any one else. This laying out of the ground in double beds need not be so executed as to have a formal appearance, though it should be sufficiently distinct to give what, in the language of art, is called the expression of purpose, and thus give the lawn of a cemetery a different character from that of the lawn of a pleasure-ground. The double beds may be slightly raised in the middle, so as to slope to the grass paths, and the surface of these paths, if only 3 in. below that of the beds, will be a sufficient distinction, when the whole is near the eye; while, at a short distance, the difference between the beds and the paths will scarcely be perceptible. We mention these things to anticipate objections on account of the supposed formality of this plan. Under every green path there may be a tile drain, which will render

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it as dry as a gravel walk. The path will answer if only 3 ft. wide, because, in carrying a coffin along it shoulder high, that space is sufficient; but 4 ft. is preferable, as admitting of carrying a coffin by hand-spokes. Where the hand-bier, to be hereafter described, is used, a 2-feet path would be wide enough.

In making arrangements for the *situations of graves*, regard must be had to the wealth and taste of the persons who will probably use the cemetery, and the proportion of situations for sumptuous tombs and monuments adjusted accordingly. At the same time, we should mark no part of the ground as exclusively devoted to any class of society, of graves or of monuments; nor should there be any part in which a monument might not be erected. In general, we would form a broad border, say from 12 ft. to 20 ft. wide, along the main roads; a border immediately within the boundary fence, of the same width as the height of the latter; a border from 8 ft. to 12 ft. wide on each side of the gravel walks; and the interior of the compartments we would lay out in beds or zones, straight or curved, with green alleys of 3 or 4 feet between. These beds ought to be of such a width as to contain two rows of graves, with the head stones of each row placed back to back in the middle of the bed, so as to face the alleys. The necessary width for this purpose is 18 ft.; which will allow 7 ft. for the length of each grave; 1 ft. at the head of each grave, on which to erect a headstone, or other monument not exceeding 1 ft. in thickness nor the width of the grave; and 1 ft. at the end next the walk, for a foot-stone or number. This head-stone or monument, it may be observed, should in no case be built on the soil, but on two brick piers brought up from the bottom of the soil to the surface of the ground, in the manner to be hereafter described.

The directions of the *roads, walks, and green paths*, is partly a matter of necessity, and partly of design and taste. Where the surface of the ground is hilly, undulating, or otherwise irregular, winding roads become necessary; but where the surface is tolerably even, whether a uniform slope or a flat approaching to a level, the choice lies between straight lines and curvilinear ones. The direction of the roads and walks, and, consequently, the whole of the interior arrangement of the cemetery, are thus in a great measure controlled by the character of its surface. In general, straight roads and walks are greatly to be preferred in a cemetery to winding ones, not only as admitting of a more economical occupation of the ground, every grave being a rectangle, and every rectangle being a multiple or divisor of every other rectangle, but as contributing far more than curved lines to grandeur and solemnity of effect. If all the roads cannot be made straight, there ought, if possible, to be one broad and straight road from the main entrance to the chapel. A winding road from the main entrance, with the chapel concealed by trees, has too much the character of an approach-road through a park to a country residence. The roads may vary from 12 ft. to 20 ft. in width, according to the extent of the cemetery; the walks should not be narrower than 5 or 6 ft., nor the green paths than 3 or 4 ft.

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The *chapel, or chapels,* ought to be placed in a central and conspicuous situation, so as, if possible, to be seen from all the prominent points of view along the roads and walks. At the main entrance there may be a lodge, or lodges, in which the sexton or superintendent of the ground may reside, and in which also there ought to be an office for the cemetery books and plans, or duplicates of them, and for receiving orders for funerals, &c. One lodge will generally be found preferable to two, because, where lodges are of such a size as to be useful, and are widely separated by spacious gates, they attract attention as separate objects, and do not group together so as to satisfy the eyes as a whole. If there are two separate lodges with intervening gates, the lodges ought not to be higher than the piers between the gates; and they ought to seem rather as massive terminations to the gates than as lodges, in short, as a part of the facade. A striking example of the bad effect of two large lodges, is afforded by the Nunhead Cemetery. The Abney Park Cemetery shows a judicious combination of two lodges with gates between; there is a very good single lodge at the west entrance to the Tower Hamlets Cemetery; and the Kensal Green and West London Cemeteries, afford examples of the lodge and gateway combined in one edifice, the gateway forming an arch through it. Where it is considered absolutely necessary to have two lodges, either to a cemetery or to the park of a country residence, they ought to be combined with the piers of the gates, as at the Abney Park Cemetery; formed into one pile of building with the gateway, as at the West London Cemetery; or one lodge ought to be much larger and higher than the other, in order to form a central mass or axis of symmetry, or, in Hogarth's language, to form the apex of the triangle.

A *yard and sheds* for the cemetery tools, implements, and other cemetery furniture, including a carpenter's shop, may also be conveniently placed near the lodge; but where the cemetery is large there ought to be two or three sheds for planks, barrows, &c., in different parts of the ground. In most cases a reserve ground for spare earth, produced from time to time as brick graves or vaults are formed, for rubbish of various kinds, and for nursing plants, to be placed over the graves when wanted for that purpose, may be requisite. On a large scale, a mason's yard with sheds is essential; unless, which is much the better mode, there should be an establishment of this kind in the immediate neighborhood, by which all the brick and stone work would be done by contract.

On the introduction of *trees and shrubs* into cemeteries, very much of their ornamental effect is dependent; but too many trees and shrubs impede the free circulation of the air, and the drying effect of the sun, and, therefore, they ought to be introduced in moderation. They ought not, as we think, to be introduced in masses in the interior of the cemetery, nor in strips or belts round its margin, unless under very particular circumstances. Every mode of introducing trees and shrubs, which is identical with that practiced in planting parks and pleasure-grounds, is to be avoided, as tending to confound the character and expression of scenes which are, or ought to be, essentially

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distinct. Independently of the injury done by masses and belts in impeding the free circulation of the air, they prevent the ground on which they stand from being occupied by graves; and though there may be no immediate occasion for so occupying that ground, yet an arrangement which seems to be at variance with, or at least to have no reference to, the purpose for which the cemetery was formed is unsatisfactory. There is evidently not the same objection to single trees or single shrubs; because, in whatever manner they may be placed, still, between and among them, graves may always be formed. There is a specific objection against boundary belts, which is, that they occupy a space that might be advantageously laid out as a broad border for tombs of a superior description, with a gravel walk in front accompanied by another border on the opposite side. For the same reasons that we would not introduce trees and shrubs in masses, we would not, in the case of cemeteries on low or level ground, plant trees which produce bulky heads; but confine ourselves chiefly to kinds having narrow conical shapes, like the cypress, the form of which not only produces little shelter or shade, but has been associated with places of burial from time immemorial. Almost all the kinds should be evergreen and of dark foliage; because the variety produced by deciduous and flowering trees is not favorable to the expression either of solemnity or grandeur. Evergreen needle-leaved trees, such as the pines, firs, junipers, yews, &c., we should prefer; because, when their foliage drops, it produces much less litter than that of broad leaved trees, such as the holly, common laurel, evergreen oak, &c. On very hilly cemeteries we would introduce round-headed trees along with conical shapes, but still chiefly confining ourselves to evergreens, such as the ilex, Lucombe oak, holly, the dark-foliaged pines, &c.

Supposing all the roads, walks, and green paths laid out, or their situations fixed on, and all the beds and borders also laid out, then we would dispose of the trees and shrubs in the following manner. Along each side of most or all of the main roads, whether straight or curved, we would plant a row of trees parallel to the road, and at regular distances, so as to form a running foreground to the interior of the compartments, and to whatever there might be of distant scenery. The kinds should be pines and firs of dark foliage. In roads and walks in the direction of east and west, we would either plant the trees farther apart, or plant narrower-growing kinds, such as the common cypress, the Irish yew, the Swedish juniper, the fastigiate abor vitæ, &c. At many of the intersections of the squares, in those cemeteries where that mode of division is adopted, we would plant provisionary trees, of a kind strikingly different from every other planted in the cemetery, in order to distinguish the angles of the squares at first sight, with the number-stone at their base, to be taken up when it became practicable, or desirable, to substitute obelisks, square pillars, or other monuments, for them. Along the centre of the beds adapted for double rows of graves, we would plant trees or shrubs at regular distances, with the intention that, in this and in all other cases, whatever, except along the main approach from the

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entrance to the chapel, the trees should be taken up and replanted, or removed altogether, when necessary, so as to suit the position of the graves.

With respect to the kind of trees, we would, with very few exceptions, plant only those evergreens which have naturally dark foliage and narrow conical heads, or which admit of being pruned with little difficulty into such form; because, such forms not only interfere less with ventilation, sunshine, and the performance of funerals, but, more especially when of a dark color, are naturally, from their great height in proportion to their breadth, more sublime than spreading forms; as well as artificially so, from their being classically and popularly associated with places of sepulture. For the main avenue we should prefer *Pinus taúrica*, *P. Pallasiàna*, or *P. nígricans*; if the situation were favorable, the evergreen cypress, or the Juníperus excélsa, found to be a very hardy conical tree; and, if very unfavorable, the red cedar, or the common spruce. The pines and spruces grow rapidly, and admit of being cut into cones as narrow as may be desirable; but, to render this cutting unnecessary, the red cedar, and some of the rapid-growing conical junipers, might be employed. Along most of the gravel walks, and along the centre of the double beds, we would plant, for the most part, only fastigiate shrubs, such as the Irish yew, Irish and Swedish juniper, *Juníperus recúrva*, and some other junipers, and the arbor vitæ, box, common yew, &c. We would not plant, as a part of a general plantation of a cemetery or churchyard, weeping willows, weeping ashes, weeping elms, or trees of that kind; because we think that these trees, being of such marked and peculiar forms, are best adapted for being used only occasionally, for particular purposes; and, therefore, we would leave individuals to select such trees, or trees or shrubs of any other singular shapes that they thought fit, and have them planted over their graves or tombs. Thus, while the general plantations of the cemetery maintained a uniform grandeur and solemnity of expression, the singularly shaped trees and shrubs employed by individuals, would confer variety of character.

A cemetery planted in the manner described, will have a distinctive character, and one quite different from that of any of the cemeteries that we have seen, either in London or elsewhere. The cemeteries, according to our ideas, bear too great a resemblance to pleasure-grounds. That they are much frequented and admired by the public, is no proof that they are in appropriate taste, but only that they are at present the best places of the kind to which the public have access. When our public parks and gardens are extended and improved as they ought to be; when they are ornamented with fountains, statues, immense blocks of different descriptions of rocks, (named) and with models of celebrated buildings, as covered seats and places of temporary repose or shelter; when they abound in singing and other birds, and aquatic fowls, and contain every variety of tree and shrub that will thrive, and many kinds of herbaceous plants; and when they are perambulated, during a certain number of hours every summer's day, by a band of music, as in some of the public gardens in Germany;

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then will the necessity, as well as the propriety, of having a distinctive character for cemeteries be understood and appreciated.

The planting of *flowers* in cemeteries is very general, not only in the margin of masses and belts, and in beds, as in pleasure-grounds, but on graves. For our own particular taste, we would have no flowers at all, nor any portion of ground within a cemetery that had the appearance of being dug or otherwise moved for the purpose of cultivation. A state of quiet and repose is an important ingredient in the passive sublime; and moving the soil for the purpose of culture, even over a grave, is destructive of repose.

Nevertheless, as the custom of planting flowers on graves, is common throughout Europe, and of planting them in beds is frequent in the cemeteries about London, arrangements for this purpose must be provided accordingly. We would never plant flowers or flowering shrubs in the margins of masses or belts, or in beds or patches that might be mistaken for those of a lawn or a flower-garden; but, to give them a distinctive character, we would plant them in beds of the shape of graves or coffins, raised above or sunk beneath the general surface, and only in situations and on spots where at some future time a grave would be dug. For example, two graves are seldom dug close together, but an intervening piece of firm ground is always left of width sufficient for forming a grave at a future time; the object being to have, if possible, at all times, firm ground for the sides of a grave which is about to be excavated. Now, on these intervening spots alone would we plant beds of flowers, or of roses, or of other flowering shrubs. When flowers, shrubs, or trees are planted on occupied graves, it is done by individuals according to their own taste. The most highly ornamented cemetery in the neighborhood of London, as far as respects plants, is that of Abney Park, in which as already mentioned, there is a complete aboretum, including all the hardy kinds of rhododendrons, azaleas, and roses in Messrs. Loddiges' collection; and in which also dahlias, geraniums, fuchsias, vebenas, petunias, &c., are planted out in patches in the summer season.

To be Continued.

Description of the Roofs over Buckingham Palace, covered with Lord Stanhope's composition. By Peter Hogg, Assoc. Inst. C. E.

The mixture invented by Lord Stanhope, and used by the late Mr. Nash, for covering the nearly flat fire-proof roofs of Buckingham Palace, is described in the paper as being composed of Stockholm tar. dried chalk in powder, and sifted sand, in the proportions of three gallons of tar, to two bushels of chalk, and one bushel of sand, the whole being well boiled and mixed together in an iron pot. It is laid on in a fluid state, in two separate coats, each about three-eighths of an inch in thickness, squared slates being imbedded in the upper coat, allowing the mixture to flush up between the joints the whole thickness of the two coats, and the slates being about an inch. The object in imbedding the slates in the composition, is to prevent its

becoming softened by the heat of the sun, and sliding down to the lower part of the roof, an inclination being given of only 1½ inch in 10 feet, which is sufficient to carry off the water, when the work is carefully executed. One gutter, or water-course, is made as near to the centre as possible, in order to prevent any tendency to shrink from the walls, and also that the repairs, when required, may be more readily effected. It is stated, that after a fall of snow it is not necessary to throw it from the roof, but merely to open a channel along the water-course, and that no overflowing has ever occurred; whereas, with metal roofs it is necessary to throw off the whole of the snow on the first indication of a thaw. These roofs have been found to prevent the spreading of fires, and it is stated, that on one occasion, to test their uninflammability, Mr. Nash had a bonfire of tar barrels lighted on the roof of Cowes castle. Another advantage is stated to be the facility of repair which the composition offers, as if a leak occurs, it can be seared and rendered perfectly water-tight, by passing a hot iron over it; and when taken up, the mixture can be remelted and used again. The author proposes to obviate the disadvantage of the present weight of these roofs, by building single brick walls at given distances, to carry slates, upon which the composition should be laid; instead of filling the spandrils of the arches with solid materials, as has been hitherto the custom.

The reported failures of this species of covering at Mr. Nash's house in Regent street, and in other places, are accounted for by the composition having been used in one thin coat, laid upon an improper foundation of laths and tiles. The durability of the roofs, which were carefully constructed with good materials, has been, it is contended, fully proved at Lord Palmerston's house, which was covered with the composition in 1807; Lord Berwick's, in 1810; Sir James Langham's, in 1812; the Pavillion, at Brighton, in 1816 and 1823; and nearly the whole of Buckingham Palace, in 1826 and 1829; the latter roofs are stated to be in perfect order at the present time, and have scarcely demanded any repairs since their completion.

Remarks.—Mr. Poynter presented a drawing of the mode of setting the pots for melting and preparing the composition, the proportions of which he stated somewhat differently from those given in the paper. Three measures of ground chalk, dried and sifted very fine, were mixed and kneaded up with one measure of tar; these ingredients were melted in an iron pot, set in such a manner that the flame should not impinge too violently upon it. The first or "skimming" coat of the covering being laid on of a thickness of $\frac{3}{16}$ inch, the finishing coat was composed, by adding to the former mixture, three measures of hot sifted sand, well mixing the whole together; the composition was laid on with a tool similar to a plasterer's trowel, but much stronger. Mr. Nash, when he first tried the composition, found that the surface became disintegrated by exposure to the weather; he, therefore, added the slates imbedded in the second coat, and subsequently never used the mixture without them.

Mr. Nixon, in reply to questions from the President and other members, stated, that he was employed under Mr. Nash when the

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palace roofs were executed, and he could bear testimony to their durability and soundness, The roofs at East Cowes castle, which were covered with the composition in the year 1808, and those of the Pavillion, at Brighton, in 1816, were now in as good a state as when they were finished. The failure at Mr. Nash's house, in Regent street, arose from the roof having been originally composed of mastic, which soon cracked. One coat of the Stanhope composition was spread over it, to stop the leaks, but it was insufficiently done, and ultimately Mr. Rainy had a new roof, properly constructed, with two coats of composition, which had remained sound to the present time. The price of these roofs, when well constructed by the person who did those of the palace,* was about five guineas per square.

Mr. Hogg observed, that the chalk was only exposed to such a heat as would evaporate any moisture it contained. The weight of the two coats of Stanhope composition, including the slate imbedded in it, was about 12 lbs. per superficial foot.

Mr. Sibley considered the Seyssel Asphalte, when carefully laid, preferable to any composition of a similar nature; he had used it extensively, and was well satisfied with it, both for roofing and paving.

Mr. Hogg objected to the use of asphalte for roofing, as it was liable to injury, being of a brittle nature; it was not elastic, and it shrunk from the walls, thereby causing leaks. Lord Stanhope's composition did not possess these faults, and he did not consider that it was superseded by asphalte.

Mr. Moreland had covered the roof of the tread-mill, at Giltspur Street Compter, with asphalte, and had found it answer perfectly. It was laid on in a thickness of $\frac{3}{8}$ inch upon roofing boards $\frac{3}{4}$ inch thick, with canvas nailed on them, with an entire fall of only 9 inches; there was not any appearance of leakage.

Mr. Davidson had caused a school-room to be floored with asphalte, four years ago, and up to the present time, there was no symptom of wearing down, although the stones which were let into the floor, for supporting the desks, &c., were considerably abraded. He believed that the only failures of the asphalte had occurred from the use of inferior ingredients. Gas tar had been used instead of vegetable tar, and in those cases the result had not been successful.

Civ. Eng. & Arch. Journ.

Mechanics and Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Boilers. By Thomas W. Bakewell, Esq.

A communication from me on the above subject, appeared in the January number of this journal. Prompted by a report on the explosion of a boiler in the steamboat Medora, and composed by Mr.

* Mr. Millecn, No. 6 Frances Street, Tothill Fields, Westminster.

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B. H. Latrobe, at the request of the Committee on Publications, for the Journal of the Franklin Institute.

The subject and the error with which it is, by authority, burthened, occasioned my remarks, without any special reference to the Medora's boiler, or the opinions as held by the author of the report, for they (the opinions) are truly orthodox, and would have formed the basis of a report on the same matter, by nearly all, professionally, scientific men.

Many years have not passed, since the advocates of loss of power by the "crank motion" stood on equal ground with their opponents. Fewer years have passed since those who contended for a loss of power by the alternating weight of a lever beam and its appendages, when working through the intervention of a crank, stood on higher ground than those of an opposite opinion; and I well remember the time, when my ideas, especially on the latter branch of the subject, were considered fatally heretical.

I believe I am now safe in saying, that the crank and the lever beam have found their proper places; and most assuredly the cylindrical boiler, will, also, ere long, assume its correct position. I rejoice that my communication, above referred to, has elicited notice. Mr. Latrobe has replied to it in the June number of this journal, which this is intended to meet. The question before us, is, whether steam of a given density, in a cylindrical boiler, exerts a force to rend or part said boiler at any one and every point of its circumference, with a force equal to the pressure which the steam would give, on a space equal to the semi-diameter of the boiler, or a space equal to the quarter circumference—making a difference as 1. to 1.57. The sanctioned and received rule gives the former, while I contend for the latter.

Let it be recollected that the upper and lower points of the boiler, are selected as the points of investigation, merely because they are of easy reference, and that a quarter of the circle only requires to be considered for any one point, as it embraces all the varieties of direction, from vertical to horizontal.

Mr. Latrobe states that "no force oblique to the direction pursued by the body to which it is applied, can operate with its full intensity upon that body; but must expend a portion of its energy upon some other object."

Undoubtedly if that other object be foreign to, and independent of, the body originating the force; but with the boiler, the obliquity, as well as the direct action, must be disposed of within itself, we cannot form the statical triangle without an object distinct from the boiler. When opposing forces are oblique to each other, the primary force governs, and the derivative or resistance, has the obliquity—then, *the required intensity of resistance, to balance a given force, is proportional to its obliquity with that force.*

Mr. L. continues, "Mr. Bakewell's error seems to me to consist in losing sight of this elementary truth, for in using the semi-circumference, instead of the diameter, in his estimate of the pressure, at the extremities of the latter, he omits the resolution of the radial forces into their operative and inoperative elements, and assumes them to

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act with their full intensity to tear the cylinder asunder, notwithstanding the greater or lesser obliquity of every one of them, excepting the single central one, perpendicular to the diameter."

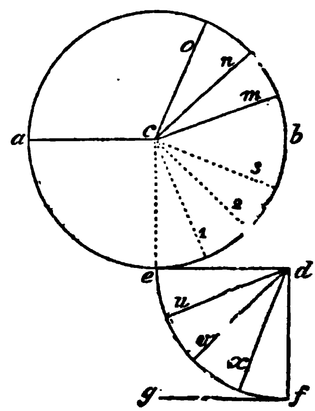
I have not lost sight of this circumstance. The "operative" force at any one point, is, (I suppose) on the received rule, as cosine to radius of the boiler; and for any given space on the circumference, as the vertical base of that space.

Having referred to the crank, permit me to make further use of it, and to observe that this 57 per cent. of difference in our estimates, happens to be the exact amount of mechanical effect which the crank would gain over its present mode of acting, provided the power throughout its circle acted on it at right angles, as it now does at two points only. Or, perhaps, more familiarly to my readers, there is a loss in the present mode of action of 37 per cent. on the 1.57 which *would* be the effect, if, as above, supposed.

As before stated, a quarter of the circle, whether of crank or boiler, is sufficient for illustration of the principle sought. Then let the connecting rod (indefinitely long) from a cylinder, be attached to a crank at right angles, and a series of *other cranks*, project at equal and indefinitely small distances from the same centre through the greater circle; let each and every of the cranks be equally impressed with a given force at right angles to each respectively, then the required resistance on the piston, to oppose and hold these cranks in equilibrio, would be the sum of the pressures on the cranks.

Here we have uniform powers distributed over, and represented by, the greater circle, and conforming to its various directions in *one* direction, represented by a line equal to the semi-diameter, or half stroke, and the obliquities of the resistances and consequent increased intensities, represented by the difference in length inversely (or of motion supposed) between said resistances on the semi-diameter, and the powers on the quarter circle.

The radial action of the steam on any one point, for instance, at the bottom of the boiler, may be viewed in this wise. The boiler may be considered as suspended at *a* and *b*, by the pressures on the upper or opposite half, if you please, (which is true) and the radial force at *e*, acting downwards, through the curved arm, or lever *e*, *a*, the *virtual* length of which is only as *a*, *c*, equal the semi-diameter. By tracing the radial force back and upwards from *e*, by the dotted line *e*, *c*, to its supposed source at *c*, this *virtual* lever is met, and the action becomes apparent; and for each point of radial action on the boiler, shown by the dotted lines, the resting point of the lever so formed, will in like manner be at right angles to such radial force, as 1.*m*—2.*n*—3.*o*



Thus we have a series of cranks or levers with varying points of rest, and the force always at right angles. These cranks and their combined effect may be shown concentrated, by having a common centre or point of rest, as at *d;* then *u, v, x,* represent levers or cranks, *m, n, o,* respectively, with the several equal forces of corresponding directions at right angles to them.

Now, if the whole quarter circle *e, f,* were filled or occupied by cranks under like conditions, the sum of their forces would be expressed by the said quarter circle *e, f,* and the required horizontal resistance to balance them, if represented by or on the line *g, f,* equal to the semi-diameter, must compensate by intensity what it is deficient in length (or motion supposed).

Mr. L. offers as illustrative of the fallacy of my position, that a ring of iron one inch in width, be filled by a solid disk of some hard body, also one inch in thickness; then divide the disk equally in two parts, and let a wedge be driven with a certain force tending to separate them, or he adds, "what would be better," to introduce steam into the fissure. With steam in the fissure, the disk and ring fall short of making a parallel case. It is plausible, so far as the circular form is preserved, and it is evident that the force to part the ring at top and bottom, would be no more than the pressure on the diameter. But the ring is not under the same conditions as with steam alone; in the latter case, the force acts in all directions with the disk; it is confined to one direction (say horizontal), and it is immaterial whether the steam be prevented from acting upwards and downwards (or largely partaking of those directions), by the interposition of a solid body, or that the force of the steam should be conteracted in those directions by vertical ties. The rule of the force to part, being as the diameter, would be good in either case. The ring near the horizontal ends of the disk, would be in effect converted into a stiff or solid material, losing its flexibility. With the disk, the ring is not under so much pressure outwards near the top and bottom, as with steam, notwithstanding its retention of the circular form: for if the steam were admitted between the ring and the disk—say as far as an angle of 30° on each side the vertical fissure—the top and bottom would be distended, the vertical fissure closed, and the ring cease to be circular; and if the fissure were made of sufficient width not to impede the distention at top and bottom, the ring would be held by the steam acting as above, in equilibrio of an irregular, oval figure.

This last assertion may require some strengthening, which I will endeavor to furnish. Imagine a square, the upper and lower sides of sheet iron, and the vertical sides of strong cast iron, and all the sides may be supposed of one inch in width, as with the ring; then subject the square to the action of the steam. If the upper and lower sides were perfectly flexible, and at the same time unyielding lengthwise, any force, however small, by the steam, would compel the approach of the cast iron sides, however strongly propped apart, or breakage of some part must ensue;—such is the extreme of the theory. Practically, it is enough to say that by the force of moderate steam, the sheet iron top and bottom would each be distended into a figure

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This singular figure, in the aggregate of an oval form, having a flat place in each of its longer sides, would be held balanced and at rest by the contained steam—which diameter would my opponents take, in computing the parting force?

I shall not venture on the field of speculation here opened, lest an error in a collateral branch of the subject might unjustly taint the now important one at issue.

As to the fact of the upward and downward pressures on the sheet iron sides, being more effective than the lateral pressures on the cast iron sides, I shall limit myself to the repetition of a remark in my first communication, that they (the sheet iron sides) sustain the pressure "*in the disadvantageous manner of a string stretched horizontally bearing weight.*"

Is it more than fair that the ring and disk be now presented by me, as an exposition of the received theory, by which, as I have formerly said, "the horizontal action of the steam is alone considered," and showing its insufficiency to fulfil the actual conditions of the case. Before closing this article, let me put the following simple question: A weak place is in the boiler at top or bottom,—will a *vertical* tie near it, support, or relieve the weak place from a portion of the parting strain? if yea, what is the rationale? By the tenor of the latter part of Mr. L's. paper, I would fain hope that he is almost pursuaded to be a heretic. Were he so altogether, his loss of caste by the convertion, would endure but for a season.

Cincinnati, 27th June, 1843.

On the Blowpipe. By Theo. F. Moss, Mining Engineer.

(Continued from Vol. V, page 287.)

After examining a substance in a glass tube, and in a tube closed at one end, another portion of the substance must be heated, held in platina pincetts, before the flame of the blow-pipe, to see if it is fusible and to what degree; and for this purpose a scale recommended by Kobell may be used with advantage. This scale is, 1. grey Antimony ore, which melts in a common flame; 2. Natrolite, which melts in fine splinters in the inner flame, and in large pieces easily before the flame of the blow-pipe; 3. Adular does not melt in the flame of the lamp, but easily before the blow-pipe flame; 4. Almandine melts with difficulty before the blow-pipe flame; 5. Augite melts with more difficulty than almandine, but easier than 6. Bronzite, which can only be fused before the blowpipe on the edges of the finest splinters. It is advisable to have splinters of these minerals at hand for the sake of comparison, and the difference of fusibility of any mineral between any numbers of the scale is computed in decimal places, in the same manner as in determining the hardness. The relative fusibility of minerals, is of great use in determining the silicates from one another, which generally have the same chemical reactions before the blow-

pipe, but have different degrees of fusibility. Care must be taken to use fine splinters of the mineral, as by using thick pieces, a mineral often seems infusible, when in reality it can be fused with ease; and with little practice the degree of fusibility of any mineral, as compared with the scale, can easily be determined.

Minerals heated in the platina pincetts often color the flame, in which case in order to determine correctly the color, a pure blue flame must be blown, and the mineral held at the edge of the flame, and thereby the presence of some substance may be determined with great certainty. An intense violet flame is produced by potassa; but if the same mineral contains soda or lithia, the flame will be colored either yellow from the soda, or red from the lithia. A green flame is produced by sulphate of barytes, the ores of telluriam, and some of the ores of copper. Many of the compounds of sulphur, arsenic, and antimony cause a pale, bluish-green flame. A beautiful blue is produced by the muriate of copper, muriate of lead, and seleniuret of lead.

After having heated a substance in the pincetts, it is laid on curcuma paper, and wet with a drop of water, and if the paper is colored brown, or brownish red, it shows an alkaline reaction, this alkaline reaction is shewn by all the combinations of the alkalies and alkaline earths, with carbonic acid, sulphuric acid, nitric acid, muriatic, and fluoric acid, and with water.

After having thus examined the substance, the mineral is to be examined on charcoal; if the substance is in powder, it must be made into a thick paste, and put on the coal. Most of the metals melt in the coal before the blow-pipe flame, and are oxidized, except gold and silver; platina, iridium, palladium, rhodium and osmium, are infusible.

Molybdinum, wolfram, nickel, and iron, are also infusible; their oxides can, however, be reduced by the inner flame. Most of the sulphates are fusible on coal, and are mostly changed to the oxides when sulphurous gas is disengaged. Most of the metallic oxides are infusible before the blow-pipe, but are generally more highly oxidized by the outer, or deoxidized by the inner flame. The following few oxides are fusible: the oxide of lead, bismuth, antimony and copper.

Salts soluble in water, melt before the blow-pipe flame on coal, but are mostly decomposed and leave their base on the coal. The alkaline salts are either drawn into the coal, or melt into a bead; most of the insoluble salts melt into a bead, which, on cooling, becomes crystalline.

Some substances on being heated on charcoal, undergo a change of color, by which they may be easily recognized; zinc oxide is white when cold, but becomes yellow when heated; and the original color of many substances when heated becomes much darker. A very important means of knowing minerals is their sublimate, that is, the volatile oxide which is deposited on the coal around the mineral when heated in the oxidizing flame. A white sublimate is formed by tin, zinc, antimony, arsenic and tellurium; the sublimate of tin is thick, and can be reduced by the inner flame; the zinc sublimate is, when warm, yellow, but on cooling, white, and burns with a white phosphorescent flame; if cadmium is present, the zinc sublimate is surrounded by a dark

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yellow sublimate of cadmium oxide; the sublimate of antimony is also thick, and volatilizes where it is touched by the blow-pipe flame; the sublimate of arsenic is white, in thin layers greyish, and far from the mineral, and can be volatilized by slightly heating; the sublimate of tellurium is white, but has a red or dark yellow edge, and vanishes on being blown on by the reducing flame, with a green appearance.

The sublimates of lead, bismuth, and cadmium are very similar; the sublimate of bismuth, is, when warm, dark orange yellow, when cold, lemon yellow, and in thin layers blueish, and can be driven from one place to another by the blow-pipe flame, when it is partly volatilized; the sublimate of lead, is, when warm, dark lemon yellow, cold, sulphur yellow, and in other respects like the sublimate of bismuth; the sublimate of cadmium is to be seen plainly only when it is cold, its color is yellowish brown, and in thin layers, yellow, and can be volatilized by any flame.

Silver melted on coal in the oxidizing flame, gives a slight dark red sublimate; when lead is present, the coal is at first covered with the sublimate of lead, and afterwards with the sublimate of silver.

After having examined the mineral before the blow-pipe without reagents, and no satisfactory results obtained, it must be examined with reagents, which must be chemically pure, otherwise false results will be obtained.

The reagents which are used, are:

Soda, and must, in particular, be free from sulphuric acid; borax, which must fuse into a transparent colorless glass; phosphate of soda, which must also fuse into a colorless glass; saltpetre, boracic acid, powdered fluor spar, a solution of nitrate of cobalt, which must not be very concentrated, and must be free from alkaline substances; tin, iron in the form of fine wire, lead, oxide of copper, litmus, and tumeric paper.

The relation of the mineral to borax or phosphate of soda, is to see its solubility, and the color which the discolored substances give to a bead of borax or phosphate of soda in the oxidizing or reducing flame. This reaction is of great importance for metallic compounds.

Most of the combinations of manganese give when melted with borax or phosphate of soda, a glass which in the oxydizing flame is violet red, but in the reducing flame becomes colorless.

All minerals containing cobalt give these fluxes a saphire blue color; chromium gives an emerald green glass with these fluxes.

The oxide of iron and most of the minerals containing iron, give these fluxes in the oxidizing flame, a dark red color, which, on cooling, becomes paler, then yellow, and when quite cold, is colorless; in the reducing flame the glass is bottle green, and remains so when cold.

The oxide of cerium gives in the oxidizing flame with borax, a red or dark yellow glass, which, on cooling, becomes paler; in the reducing flame the glass is colorless.

The oxide of nickel gives with borax in the oxidizing flame, when warm, a violet brown glass, which, on cooling, is red brown; in the reducing flame the color disappears, and the glass becomes greyish

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reaction is the same in the oxidizing and reducing flame, as with borax in the oxidizing flame.

The oxide of copper gives with borax and phosphate of soda in the oxidizing flame, a light blueish-green glass; in the reducing flame a brownish red, generally cloudy and opaque.

The oxide of uranium gives with borax in the oxidizing flame, a dark yellow glass, which in the reducing flame is a dirty green; with phosphate of soda, in the oxidizing flame, the glass is clear yellow, in the reducing flame a beautiful green, which becomes more apparent on cooling.

Molybdic acid gives with borax in the oxidizing flame, a colorless glass, which becomes brown in the reducing flame; with phosphate of soda, in the oxidizing flame, the glass is green, but, on cooling, becomes paler; in the reducing flame it is dark, but, on cooling, becomes a beautiful green.

Wolframic acid gives with borax, in the oxidizing flame, a colorless glass, which in the reducing flame is yellow, by a greater addition of wolfram, it becomes, after cooling, a blood red; with phosphate of soda, in the oxidizing flame, the reaction is the same as with borax; but in the reducing flame, the glass bead becomes of a beautiful blue color, when the acid is free from iron, but when iron is present, the glass is blood red.

Titanic acid with borax, gives with the oxidizing flame, a colorless glass, which in the reducing flame, becomes a dirty amethyst color; with phosphate of soda, with the addition of a little tin, in the reducing flame, the bead is of a blue violet color, but when iron is present, the color is red.

The other metallic oxides color the glass beads of borax and phosphate of soda, either not at all, or yellow; the earths also do not color the fluxes, but are all soluble in them except silica, which is not soluble in phosphate of soda.

In order to prove the presence of fluorine in a mineral, a small quantity of it is melted with phosphate of soda in the end of a glass tube, when hygrometric fluoric acid is formed, which destroys the glass.

To prove the presence of chlorine in a mineral, take a bead of phosphate of soda, charged with oxide of copper, so that the bead is strongly colored with the copper, then add the mineral, and if it contains chlorine, the flame will be of a beautiful blue. Bromine and iodine have the same reaction, but bromine colors the flame bluish green, and iodine pure green.

From the above it will be seen that no two oxides have the same reaction with borax and phosphate of soda, in both the oxidizing and reducing flame; therefore, it is necessary in all cases to examine the mineral with both fluxes.

On the reaction with Soda.

When a substance is treated with soda, the two are generally melted together on coal, the substance is either applied in splinters or in

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powder, and the soda gradually added. A great many substances have the property of uniting with soda at a high temperature, and combinations are formed of which some are fusible, and some infusible. However but few belong to the fusible, viz., silica, and a few metallic oxides, viz., the wolframic, titanic, and molybdic, which, with the exception of the combinations of silica, are mostly drawn into the coal.

In order to try the fusibility of a substance with soda, if the substance is in the form of a powder, a paste is made with it and some soda; but if it is in splinters, it is covered with a paste of soda, and laid in a small hole in the charcoal, and at first slightly heated to drive off the water, and then strongly heated with the oxidizing flame; at first, when the soda begins to fuse, it is drawn into the coal, but makes its appearance again when it begins to unite with the substance, when it fuses with effervesence into a ball; but if the substance is insoluble in soda, but decomposed by it, it changes its appearance, and does not fuse into a ball.

If a substance is soluble in soda, and not enough soda has been added, a part of the substance remains undissolved, and is surrounded by a clear glass; but if too much soda has been added, the glass, on cooling, becomes opaque, therefore, it is advisable always to add the soda in small proportions, in order to see the changes which are produced by the addition of greater quantities.

A substance which is soluble in soda, if it contain sulphur or sulphuric acid, gives the glass a yellow red, or yellow brown color, according to the greater or less proportion of sulphur in the substance.

If a substance soluble in soda, is in the form of powder melted with soda on platina foil, and the fused mass has a bluish green color, it shows the presence of manganese.

If the mineral contains silica and the oxide of cobalt, the silicate of soda is formed, which will be colored blue by the oxide of cobalt.

By the reduction of metallic oxides by the aid of soda, the presence of metals in minerals, if contained in small quantities, can be detected with more accuracy than by analysis by the wet way.

If a metallic oxide is in combination with substances which render its reduction difficult, and the reduced metal difficult of determination, the mineral must be reduced to a fine powder and mixed with soda to a paste, and melted on coal before the reducing flame. The first of the soda is generally drawn quickly into the coal, therefore, it must be continually readded till no more of the assay remains on the surface of the coal. The first part of the soda serves to collect the metallic contents, and the latter to reduce the metallic oxides. After the reduction of the mineral, the part of the coal where the reduction took place, must be wet with a few drops of water, and all that part of the coal which is saturated with soda, cut out with a knife, and rubbed in an agate mortar with water to a fine powder, and slowly triturated that the coal and unreduced substances may separate easily from the more heavy metallic particles, and be easily drawn off with water from these. This must be continued till all but the metallic parts are removed from the mortar. If the mineral does not contain a reducible

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metal, the mortar will be empty, but if it contains only a small quantity of such a metal, there remains at the bottom of the mortar, shining flat spangles of the metal, if the metal was easily fusible and malleable; but a metallic powder if the metal was hard to be fused or not very malleable.

In this manner we may very plainly detect one-half per cent. of tin, and a still less proportion of copper in a mineral; if several metallic oxides are contained in the same mineral, they are generally reduced together to an alloy, sometimes separate reguli of each mineral are given.

The metals which in this manner may be reduced are molybdinum, antimony, wolfram, tellurium, copper, bismuth, tin, lead, zinc, nickel, cobalt, iron, silver and gold. Among these are some which are either totally, or in part, volatilized, and cover the coal with their oxides; to these belong antimony, tellurium, bismuth, lead and zinc: arsenic, cadmium and quicksilver are also reduced with soda, but are again immediately volatilized, and can only be obtained in a metallic form by sublimation with soda in glass tubes.

If, in reducing with soda, a metallic regulus is obtained, which is an alloy of several metals, it must be handled with borax or phosphate of soda, in the manner already described.

To be Continued.

On the Ores used at Freiberg.—Translated from the German of C. A. Winkler. By Theo. F. Moss, Mining Engineer.

At present between 180,000 and 190,000 cwt. of ore are used yearly at the works of Freiberg; of which from 60 to 70,000 cwt. are used in the amalgamation works, and the rest worked up in the furnaces.

With few exceptions all the ores are brought from the numerous mines of the Freiberg mining district, and are in a powdered form.

These ores are, in relation to their component parts, of great variety. The quantity of silver in a cwt. of ore, varies from 0 to many 100 ounces in the cwt., and some of them are of the richest description of silver ores, but the average amount is between 2 and 3 ounces to the cwt.

Some of the ores are more or less rich in lead, but the quantity of lead ores which contain more than 30 per cent., is hardly $\frac{2}{100}$ of the whole mass of ore; copper ores which contain several pounds of copper in the cwt. are but few; but traces of copper are found in most of the ores, therefore the silver from the amalgamation process always contains some copper, although the copper ores are never at Freiberg, used in the amalgamation works. About 14 to 18 per cent. of the whole quantity of ore is either poor in silver, or totally free of it, and is iron pyrites, used in the first smelting process.

The other component parts of the Freiberg ores are very various, as is to be expected from the various and numerous veins from which the ores are brought. The ordinary mixtures are quartz, hornstone

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jasper, heavy spar, and calcareous spar; fluor spar, on the other hand, is at present but seldom met with. Iron pyrites is common, but is not at hand in sufficient quantities to supply the necessary addition for the first smelting; some of the ores contain a great deal of zinc, antimony or arsenic, and iron ochre and carbonate of iron are found in greater or less quantities.

The Freiberg ores belong, on the whole, to that class of ores which are with difficulty smelted, and the most infusible kinds are those which are composed in most part of quartz or heavy spar.

It is worthy of mention that some gold is found in most of the Freiberg ores, and appears to be contained in the pyrites. The per centage of gold is, however, so trifling, that it would not cover the cost of separation. A small profit would accrue from separating the gold from the silver obtained by the smelting process from some varieties of the pyrites, were it not found more profitable to use these ores in the amalgamation, when most of the gold is lost in the reviving process *(anquickprozess)* without being concentrated in the silver amalgam.

The ores used in the amalgamating works must neither contain lead nor copper. Lead would make the amalgam impure, and the lead would be lost in the residuum; copper ores by the Freiberg amalgamation process would cause the silver to contain too much copper, and much of the copper would also be lost in the residuum.

Therefore, the ores which are used for the amalgamation *(verquickung)* contain as little lead and copper as possible, and from 3 to 4 ounces silver to the cwt. of ore, but at the same time sufficient pyrites for the decomposition of the salt used.

All other description of ores, whatever may be the proportion of silver, lead, copper or pyrites, are given over to be smelted at the furnaces.

Experiments and Observations on Möser's Discovery, proving the Effect is neither due to Light nor Heat. By Horatio Prater.

(Continued from Page 72.)

6. *As regards Impressions on Glass.*—We have already observed that heat does not seem to increase the effect of *metal* coins on glass. Neither did *long contact;* for a fourpenny piece, left a *week* on a piece of looking-glass, only left the usual spectrum, no *figure* being visible. The same remark applies to large *printed* letters. At least, some paper with these, after remaining pressed two or three days without giving any impression, was then heated for five hours, so pressed, at about 160°, but no impression was made. On another occasion, print and writing were left a week on a glass mirror without leaving an impression. When, however, thinner paper and larger letters were used, and heat and pressure applied as above for four or five hours, these letters were plainly visible; but, as appeared to me, far more easily erased than were the spectra of coins on copper plates.* A

* On a copper plate also this *thin paper* (not being well dried first) gave a permanent and very visible spectrum, the lettering being clearer than on glass: not due to oxidation, i. e.

They were produced in this case in consequence, no doubt, of the thinner paper being *moister* than that first used.

Heat does not appear to increase the effect on glass. A fourpenny piece under a shilling for three hours, at 160°, left no spectrum.

On putting a penny on a sovereign, and leaving them for three hours and a half at the above heat, I thought the spectrum of the penny slightly visible; but as the image is never so apparent as on polished metal, I shall not venture a decided opinion on this point as regards glass.

A *polished*, *boiled*, and then well dried half-crown, gave as good a spectrum on a glass plate in twenty-four hours, as did a dirty half-crown; but I thought the spectrum of the former disappeared sooner by breathing. On a far thinner glass plate, a bright, boiled fourpenny piece, left the same time, gave no spectrum at all.

7. *Polished surfaces not appearing capable of receiving the impressions.*—These exceptions from the general rule I have found to be talc, and among the metals tried, steel to a certain extent, platinum and gold.

Whether heated or not with the coins on it, I have found *no* spectrum produced on talc, except in one instance, where a tarnished half-sovereign had been pressed some days by a half pound; and even here the mere margin of the coin was *barely* perceptible.*

On steel, after remaining twenty-four hours, I found a *very* slight evanescent spectrum produced by a small piece of brass, and on *one* occasion by a half-sovereign very much tarnished; but as heat did not appear to increase or hasten the effect, we may consider steel almost unsusceptible. The spectra just named disappeared entirely after breathing *twice;* and no *permanent* spectrum was produced, though the piece of brass above mentioned was placed even on the top bar of a grate, and, of course, kept very hot, for two or three hours.

Under the head "Thinness of the plates," experiments, showing the incapability of platinum to receive images are mentioned.

The same remark applies also to gold. I kept a shilling and a farthing on two different occasions, for twenty-four hours or longer, on a well polished plate of gold, yet they *barely* left a marginal spectrum; and this spectrum, as in the case of steel, disappeared *entirely* on breathing on it twice. As the gold used was not free from the usual alloy of copper, possibly this was the cause of its receiving even the very slight spectrum it did. However this be, these experiments seem almost sufficient to establish the important general principle, viz., *that the less metals are oxidable by exposure to the air, the less is their susceptibility to receive spectra.*

oxidation in the usual sense of the term; but, on rubbing it off, the surface of the copper was left polished; there, no doubt, was some *very slight* chemical action, as large printed letters on perfectly well dried paper were not taken off on a copper plate, the heat at 160° being applied for five hours; or on another occasion, the print remaining a week on the plate, and pressure being used.

* Talc, like platinum, is not easily acted on by acid.

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8. *As regards comparative polish in metals.*—1. A new sovereign, a new half-crown, and a new farthing (all well polished) were kept on a bright copper plate, at 160° or above, on *two* successive occasions, for four or five hours. The gold and silver left only *very* slight permanent traces of their margin, the copper left none at all; but its spectrum, when the plate was breathed on, became, I thought, even rather more evident than the spectra of the gold and silver, these being likewise breathed on. 2. A *tarnished* sovereign and a *tarnished* half-crown being laid on the same copper plate, and kept at the same heat *only three quarters of an hour*, a permanent and *far more apparent* spectrum was produced, than in the former case; the *whole area* where the half-crown had laid, was covered with a whitish cloud, and the impression dimly sketched. 3. By selecting a half-penny *very much* tarnished, and letting it remain five hours on a bright copper plate, heated to 160° or so, and subsequently for thirty-six hours in the cool, a *permanent* spectrum was produced, in which all the *lettering* of the coin was *beautifully* visible; yet here was copper on copper. But as I found this impression to go off completely at a heat far below what the impression did, at experiment 5, below, the general principle, that silver gives a *stronger impression*, remains. 4. A *well polished* new sovereign and a *tarnished* sixpence being laid on a bright silver plate for four hours, and kept at 160°, the sovereign had left no spectrum, but the sixpence had left a *permanent* one, in which almost all the lettering appeared, so plainly was it visible. 5. A *perfectly* polished half-crown was laid on a pretty well polished sixpence, and a *purposely* tarnished one on a purposely tarnished sixpence, and put on the same plate with the half-penny (exp. 3, above), heated five hours and left thirty-six hours afterwards. The lettering, &c. of each sixpence was visible, but *far* more of the most tarnished; and also this was the case with that of the most tarnished half-crown, as regarded its spectrum. That of the polished was scarcely visible. But the lettering of neither half-crown was visible, though they had remained so long and been heated. This experiment also shows how much the effect is strengthened by *actual contact*. A similar experiment was made in the closed deal box (mentioned in Section 5). The copper plate was laid upon a *polished* and boiled fourpenny piece, and this on a half-crown similarly prepared; after ninety-six hours, no spectrum whatever of the half-crown was visible, by breathing or otherwise, but the fourpenny piece, in actual contact, had left the usual spectrum. The plate had remained *perfectly* polished. All these experiments show that the dissimilarity of metals is not of such importance as has been conceived: they show the difference wanted to produce the effect is a difference in brightness or oxidation, *i. e.* as far as a *permanent* and good impression, *showing the lettering, &c.* is concerned; for I find when left on the plate half an hour or so, tarnished or polished metals give equally good spectra. But in this case the spectrum is only made apparent by breathing, and of course shows *nothing* of the lettering, &c. However, even in this case, the spectrum of the tarnished sovereign disappeared less soon by breathing on it than did that of

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The same remark applies to a glass plate (see Section 6, as regards glass, &c.)

9. *Which metal receives images fastest, copper or silver?*—My experiments lead me to say copper, whether heat be applied or not. When the same degree of heat was applied, I found a sovereign produced a good *permanent* spectrum (impression) on a bright copper plate, although only an evanescent one (one seen only when the plate is breathed on) was produced on an equally well polished silver plate, placed at the same time at the same heat. When heat was not applied I found the copper received an *evanescent* spectrum first.

10. *As regards the effect of interposed substances.*—As every substance tried left a spectrum, I did not much expect that the influence would permeate any lamina, even of the thinnest description. Accordingly, when a sovereign or shilling was left twenty-four or forty-eight hours on a piece of stiff, though very thin, paper, it gave no spectrum, but the mark of the paper was alone visible. The experiment was repeated, half the coin resting on the copper plate, and half on the paper: and although it remained a fortnight in this position, the half only *in contact* with the plate was visible by breathing on the paper, leaving *its own* spectral image just as if no coin had rested on it at all.

The same experiment was repeated with the thinnest possible layers of talc, gum, cork, and whalebone, glass, plane and concave,* with the same result. Each substance left its spectrum, the part where the coin rested on such layer not being at all distinguishable. The spectral image of the square piece of talc was perfect to the minutest outline, and left its straight mark under the sixpence equally well as at other points. These experiments render it clear, that the effect is not due to latent light, for otherwise how could it happen that a coin does not leave a spectral image when left on *transparent* substances, glass, or talc, *even a fortnight?* They also show it does not depend on heat (at least alone), for a heat of 160° soon passed through thin glass and talc, and I found it impossible to keep my finger on glass or talc so placed. Yet we have seen above that even gold left two hours on talc so heated left no spectrum, permanent or temporary. So great is the effect of interposed substances, that even a *slight tarnish* on the metal exerts a very obvious effect.† One shilling was left twenty-four hours on a polished part of the plate, and another on a part of the same slightly tarnished (but yet sufficiently bright to see oneself perfectly). A very slight image only was left in the latter case, that entirely disappeared when breathed on twice, while that on the polished part of the plate remained, after being breathed on twelve or fourteen times.

* With the glass the experiment was only continued forty-eight hours; with the paper, talc, and cork, a fortnight, silver coin being used; with the whalebone and gum, ten days, gold coin being used.

† One spectrum, however, may be made on another; thus, after talc had remained eight hours on heated copper plate, and left a permanent spectrum, a sovereign put on this an hour left a permanent spectrum.

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A sovereign left twenty-four hours or above, tarnished, gave scarcely a perceptible spectrum, and a sixpence, none at all. On such a surface, a sovereign was left on two different occasions, under a penny, for three hours, at a heat of 160°, and barely left a permanent spectrum of its *outer* margin; while on a well polished surface, at same heat, the outline of the impression also would have been left as a permanent spectrum in an hour or two.

11. *Mass.*—Mr. Hunt considers, that mass exercises an influence, and increases the effect. In my experiments, however, I could not detect this. A farthing on a copper plate gave as good a spectrum as a penny, and when heated to 160°, the farthing gave far the best, though the penny had a halfpenny laid on it. A fourpenny piece, too, gave as good a spectrum as a half-crown, pressed by another above it, in the same time, the contact being equally good in each case. *The contact in these cases was made as equal as possible with the copper plate.*

12. *Does the thinness of the plate exert an influence?*—A farthing (in two experiments) pressed by twelve or fourteen pounds weight, on a polished piece of platinum foil, in thirty hours, left no spectrum at all; neither did it on a fourpenny piece, or a sovereign, or half-sovereign, when kept three or four hours at 160° under the same weight. I found a spectrum could be made on nearly equally thin zinc plates, (zinc *foil)* by leaving a sixpence on it an hour or two. Zinc not being elastic, allows the pressure to be equal. The particular chemical nature of platinum has, however, much to do with this effect; for I found that when a fourpenny piece, or another small brass metal object, was left on a highly polished lamina of steel—heated to 160° or not—a spectrum was scarcely made. That elasticity and consequent *imperfect contact*, is not the sole cause of the incapacity of thin lamina of platinum and steel, for receiving spectral images, was to me rendered *probable* by observing that coins, placed on a thick copper plate, seldom were in *perfectly* close contact, yet gave good spectra. In order to come to a more definite conclusion on this point, I got a lamina of bright copper, even thinner, and as elastic as the platinum lamina, above mentioned. Gold or silver coins left twenty-four hours on this, gave a spectrum scarcely visible; but on leaving a half-sovereign for two or three hours on it, exposed to heat of 160°, as above, and pressed down by exactly the same weight, the half-sovereign left a *permanent* spectrum very well marked indeed.

The result of this experiment obviously shows, that although thinness and elasticity may have some little effect, the principal cause for the formation of the spectrum is the peculiar *chemical nature* of the metal, and *that a spectrum cannot be produced on a non-oxidable metal, such as platinum.* Bright silver and copper plates are well known to *tarnish* by exposure to the atmosphere, (the former, perhaps, rather by forming a sulphuret, than an oxide,) but no matter how. I have also found that spectra could be formed on tin and zinc plates, both of which, of course, are oxidable. So on copper coated with mercury, the mercury in such case, no doubt, readily tarnishing: (see Sec. 7. Polished surfaces not receiving spectra). Having decided

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that the effect in question is due neither to light nor heat, to what cause, it may be asked, is it to be ascribed?

Conclusions.—1stly. As *brightness* of the plate is indispensable, and with brightness must exist an *increased tendency* to tarnish, or enter into chemical combination. 2ndly. As the plate must be of an oxidable metal, and judging from the experiments with silver and copper, the more oxidable the better. 3rdly. As the more perfectly the coins are cleaned and dried,* the less the effect, and as a dry perspiration (so to call it) must exist in a greater or less degree on all coins, since they pass through so many hands, and as perspiration is slightly acid. 4thly. As even with *clean* coins the effect† by *actual contact* must be admitted, but still is greater when there is a difference in the nature‡ of the metal; and 5thly. As when the metals are not in contact (being removed only the one-twentieth of an inch apart), no action or spectrum is evident, if the free circulation of air, and the connexion with dust be prevented—taking all these and minor considerations into account, we come to the conclusion that the effect in question is dependent on *chemico-mechanical* action, or what Berzelius has called *catalytic* action. No doubt it may be urged against this view, that the action takes place when the coins and plate are both heated, and hence quite dry. But this is no solid objection, for the adage "Corpora non agunt nisi sint soluta," is not true, as hundreds of examples in chemistry show. The very fact of heat itself increasing the effect, is all in favor of a chemico-mechanical view; for heat increases the tendency of copper to oxygenation, and tends also to volatilize any feeble acid matter on the coins. But again, if it be said the spectrum rubs off, even *when permanent and clearly defined* (as we have shown), *and leaves a polished surface under it,*—this we admit; but still this surface has suffered an *almost imperceptible degree* of oxygenation; for so slowly does this effect take place, that it is only visible when much advanced, as will be evident to any person who watches the gradual tarnishing of copper plates. Möser's discovery shows that *very slight* chemical action is often going on, *which has been previously overlooked.*

The chief difficulty that occurs to the above view, is that the effect takes place, to a slight extent, on glass; but in all my numerous experiments I have found that the effect is much *less* on glass, than on well polished copper; for in no case has a *permanent* spectrum been made on glass, even by the longest contact.‖ It will also be remembered that I found no effect whatever produced on talc. Now, the talc scratches easily, glass, of course, does not; but talc is probably less soluble in acids than glass; at least in my trials it did not seem

* Moisture much increases the effect. Thus, when one surface of a shilling was rubbed over with ink, and such surface put on the copper plate, and heated to 150°, a mark *much* more difficult to be effaced was left than when this degree of heat was applied without moisture.

† This is equally true, as will be remembered, with regard to glass plates.

‡ The *general* result of all the above experiments show this; and, of course, an alteration of affinity from contact, is far more probable when metals are different than when the same: though if one be dirty, this makes it approach the nature of a different metal.

‖ A permanent spectrum has been proved (see experiments) to be but a higher degree of an evanescent one.

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at all acted on either by nitric, muriatic, or sulphuric. To be sure, you *perceive* no effect of these on glass, but it does not seem impossible but that some *very* slight effect takes place, and that the alkali of the glass is *very* feebly acted on, as glass is a *compound* body. *Contact*, at all events, may be presumed to have an influence on the affinities of one of its elements, whether there be even the *slightest* degree of decomposition or not. Now, this influence is the catalytic influence; for it has been shown above, that without actual contact, *and when all dust is kept off*, neither silver nor copper, even at the one-twentieth of an inch from the glass plate, produces any effect, though kept there ninety-six hours. (See Sec. 4, of heat generally, end.) In consequence of this slight alteration in affinity, the parts of glass which have been in contact some time with coins or other substances, condense the breath differently from those parts which have not: hence the spectrum.

The effect of glass, *supposing it not susceptible of a gradual change by the action of air similar to oxidation*, is rather in favor of the spectrum depending on a mechanical than a chemical action. I have, in consequence, ascribed the effect to a mechanico-chemical action, or a *catalytic* action, meaning thereby an action so slightly chemical, as, in the present state of the science, to be scarcely appreciable.* The attraction of glass and oxidable metallic plates for *dust*, &c., is very great; and is, perhaps, dependent on the same cause as their attraction for oxygen. Whether or not, I feel pretty well convinced, after a laborious investigation of the discovery in question, that it is not of that wonderful character that Möser and others have supposed; nor calculated to alter our ideas of vision, or of the nature of light. On the contrary, I think with Fizeau (a short notice only of whose memoir I have seen), that no effect *of any consequence* is produced *where organic matters are carefully removed by boiling water and polishing;* for such is perhaps the philosopher's opinion just named, and in as far as our opinions agree, he has the priority. Begun by a purely catalytic action, it is only continued and developed in any *marvellous* degree, when those circumstances are present that permit it to assume a more strictly chemical character.

Lond. Athenæum.

Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.

(Continued from Page 62.)

Process of Moulding in Green Sand.—Take, for example, the front of a register grate, which is a familiar instance of light flat moulding. Its construction is that of two jambs joined at the top by a cross piece. On the back, or inner surface, it is quite flat, and is ordinarily ornamented on the face with raised figures of flowers, &c. A box is selected that will receive the pattern, and have a few inches to spare, that the pattern may be completely surrounded with sand.

* In coming to this conclusion, I have not forgotten another difficulty, viz., why a well *polished* and boiled copper coin produces a spectrum on copper plate. The effect, even when continued an hour or two at a heat of 160°, is *very* slight, and I found it to disappear entirely by twice breathing on the plate. *Contact* then, of the same metal SLIGHTLY modifies chemical properties; such, on the present view, is the inference to be drawn from this fact.

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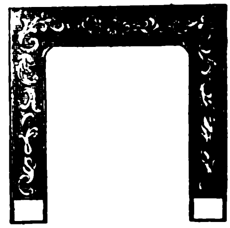
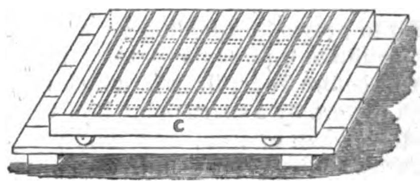
The pattern is then laid down either on the surface of a bed of sand, prepared in the upper box, which is lying inverted on the ground, or on a flat board of sufficient size to support it at all parts. In either case the pattern is laid down on its back; there is next thrown over this a layer of fine sand of an inch deep, constituting the facing of the moulding. It is passed through a sieve to detain the coarser parts. Then, upon the board or upper box, which we shall call A, the drag-box, B, is placed in its proper position in respect to the pattern. The annexed figure shows how things now stand.





It is necessary to spread the facing of sand before laying down the box, as its ribs prevent the equal distribution of the sand over the pattern. Then a larger quantity of sand is passed through a riddle which saves the small stones and other refuse in the sand. An additional quantity of the common sand is thrown in by a shovel, and the whole is now rammed down by the flat rammer as equally as possible. This is facilitated by a considerable depth of sand having been laid on, as inequalities in the force of ramming are diminished at the surface of the pattern. The box is again filled up with sand and rammed all over with the round-faced instrument. When the sand is properly set, and squared flush at the surface with the box, B, the whole is turned over, (avoiding sudden shocks of any kind, which tend to loosen the sand) and well bedded on the ground with the box B undermost. The box A, or the board, as it may happen to be used, is lifted off, and the temporary bed of sand in the box A is destroyed. The upper surfaces of the sand in the box B, and of the pattern imbedded in it, are cleaned and smoothed by the trowel, so that the surface of the sand is made flush with that of the pattern all round, and also meets the edges of the box. This forms the *parting*, or place of separation of the sand in the two boxes; and that they may afterwards separate properly, dry sea sand is sprinkled over the parting surface, and has the effect of preventing the adhesion of the sand to what is afterwards superimposed, by entering and drying its pores. The box A is now laid on the other, guided by the pins, and both are fastened together by the hooks. In bringing them together their meeting surfaces ought to be cleared of sand so as to make them bear freely and steadily. Preparations are now made for the construction of the *gates*, or passages, for the iron from the external surface into the mould. In the moulding of a register-grate front there are usually four gates constructed, into which the iron is poured simultaneously. The necessity for having so many openings for the iron must be obvious, on considering that iron rapidly solidifies

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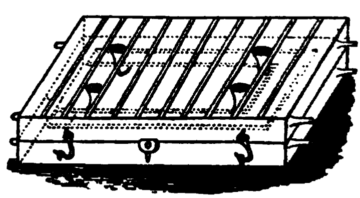
as it cools from a melting temperature, and, of course, *sets* in the form of the place it occupies.

To provide for the gates to the moulding, four taper pins of wood are struck in the sand of the lower box at a short distance from the pattern, projecting upward between the ribs of the upper box. Sand is, as before, thrown into this box, covering the flat side of the pattern, and is rammed between the ribs until the box is filled flush with itself. The pins are now withdrawn, and the holes formed by them are widened at the top into bell-mouths to receive the iron the more readily, and are well smoothed there to prevent the metal from carrying in with it any loose sand. The upper box is now taken off with care, to preserve the impression of the upper side of the pattern; and the edges of the moulding in the box B, in contact with the pattern, are wetted with a swab to make the sand, at these corners, the firmer, and to prevent crumbling on withdrawing the pattern. Still farther to facilitate this, as the pattern fits closely in its bed, it must be loosened before being drawn, which is simply effected by taking hold of the pattern by a sharp point, if of wood, or by studs, which are riveted into it when of iron, and gently tapping them laterally and downwards. The pattern is next drawn slowly out of the sand, and it often occurs that the moulding is broken at one or two places, in spite of these precautions, and especially if there be much carved or ornamental work on the pattern. The moulder has, therefore, in the first place, to repair the damages by adjusting disjointed parts, and making up fractures by the addition of sand. All the more prominent and most exposed parts of the moulding, as the extremities of the ornaments, are treated with a touch of the swab, which must be lightly applied so as not to spoil their sharpness. This process, indeed, with that of applying the blackening, now to be described, are the most difficult parts of the art of the flat-moulder. The blackening has now to be applied, and it must, by some means, be pressed down upon the mould at every part, and made to adhere to its surface. To effect this, pease-meal is used—it is first dusted thinly over the surface of the mould. It rapidly absorbs the damp of the surface sand, and is converted into a pasty matter. The blackening is next dusted over the newly formed paste, and over all, the pattern is placed in its position and pressed down. Thus the blackening is made as smooth as the pattern, and is at the same time well held down to the sand. Channels are now scooped out of the surface of the sand, joining the gate-holes to the moulding; and if the pattern be thin, each channel is widened as it joins the mould to afford a sufficient inlet for the iron. They are slightly swabbed round the mouth to confirm the edges against the abrasive action of the iron.



Having finished the moulding, and got it in order for the reception of the iron, the upper box is finally put on the under one in its place, and fastened down upon it.

the gates leading to it from the surface.

There are several points in the practice of green-sand moulding generally, to which great attention must be paid. In the preceding account, we alluded to the necessity of the sand being rammed as uniformly as possible. Now, it may be too closely rammed altogether, so as to impair its capability of conducting away the confined air, and the gases generated by the heat. There must be a degree of ramming applied proportioned to the heaviness of the casting. If the sand be too closely rammed, the current of iron flowing over the moulding, is agitated by the air not being allowed to pass freely off. In consequence it breaks up the sand and heaves it to the surface, and it is easy to see that this produces excrescences on one side of the casting, while corresponding deficiencies exist, from the same cause, on the other side. If, again, the sand be too loosely rammed, the iron by its weight presses it outward off the moulding, which renders the surface uneven, and swells the casting. Moreover, a certain degree of humidity in the sand is necessary for the goodness of the casting. When the sand is deficient in moisture, the iron is apt to penetrate its pores on the under surface, and so detach the particles of sand there, producing an effect similar to that occassioned by over ramming. On the contrary, if there be an excess of dampness in the sand, the iron, by the sudden formation of aqueous vapor, is frequently repelled altogether, and ejected at the gate like shot. Should this not take place, though the iron may make its way through the mould, the bubbles of vapor form cavities in the casting towards the under side principally, as this side bears all the *run* of the iron passing over it, and is thus more severely tried than the upper side, the iron simply rising to that side, and is there at rest. Excess of dampness, and of over-ramming, are thus nearly alike in their effects, and are the more dangerous extremes. In cases of very large castings, if the air, expanded by the heat, and the other gases generated, do not find a ready vent, they burst through every resistance with explosive energy.

The quantity of blackening to be applied must also be a particular quantity. In noticing, in a former part of this paper, the nature of blackening, and the manner in which it is operated upon by the iron, reference was made to the continued evolution of gas by combustion. If then, by the action of the iron upon the blackening in the mould, too much gas be formed, it collects in globules, and forms corresponding indents in the casting. The skill of the green-sand moulder consists in so laying on the blackening as to produce equilibrium between the antagonistic forces of the iron advancing, and the resistance of the gas produced. After having been pressed down by the pattern, the loose blackening left is rubbed off and blown away. When this is not attended to, the blackening is raised in layers from the surface by the iron, and deposited in other positions, giving the casting, when cool, a rough, clouded appearance. In forming the surface of the blackening upon ornamental moulding, by pressing down the pattern upon it, care must be taken that the pattern be perfectly dried before

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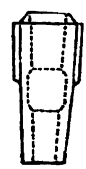
being laid over the blackening; for if at all damp, this will adhere to it, and take the pease-meal with it, and so destroy the moulding. And even though it be quite dry at first, yet it may, by lying too long in the sand, contract damp, and so spoil the mould. Swabbing is avoided when not essentially necessary, as the formation of vapor, by the contact of the iron with the water, is, as before noticed, apt to agitate the current, and make the flow irregular. The object of forming the gate to one side of the moulding, is to check the violence of the iron in motion, and to introduce it with regularity. Were the gate formed directly over the moulding, any delicate ornamental work below would be worn off by the continued action of the iron, though certainly it may be so placed, if the moulding at that part be plain. We noticed the necessity of a number of gates to the moulding. The number of these varies with the extent of the surface of mouldings in general, and also according to their thickness. A comparatively deep moulding might be well filled by only one gate, while another of just the same horizontal surface, but shallower, would require two or more gates. In short, there must be as many gates as are requisite to ensure the metal's having thoroughly filled the mould while it is yet liquid. The iron, should, therefore, be run in as quickly as possible to fill the mould completely, and this is especially to be attended to in cases of light-flat, and hollow moulding, as in these the extent of cooling surface is great, compared with the depth or thickness of the iron.*

Before dismissing the subject of light-flat moulding, one other elegant example may be described, introducing the use of three boxes for a moulding. The instance referred to is the moulding of the cast iron bushes, which are fixed in the naves of the wheels of wagons and other vehicles, to sustain the wear of the axle.

The annexed figure is a sketch of an ordinary bush for cart wheels. The dotted lines show the form of the interior, which is a tapered hole. At the middle of the length, as shown, a chamber is formed in the bush, so as to surround the axle —its object is to contain the grease for lubrication. These bushes are always cast in pairs, and the cores for them are cast iron pins, having the form of the axles for which they are intended. These pins, which serve for many successive castings, are turned and polished in the lathe,



for the purpose of communicating a smooth surface to the interior of the bushes, by which the expense is avoided of boring them out which would be necessary, were sand cores employed.

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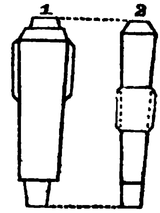

The pattern of the bush is solid, and has, in addition, a core print on each end to steady the core. This is shown by fig. 1, annexed. Fig. 2, shows the core extended at the ends in correspondence with the prints. Round the middle of its length a

* Mr. Neill's patent tiles for roofs afford a remarkable example of the extreme thinness of casting practicable. These tiles are each 18 inches by 6 inches, and weigh 28 lbs. per square yard, which gives one twenty-fourth of an inch for their thickness. Small as they are, they require two gates, on account of their extreme thinness.

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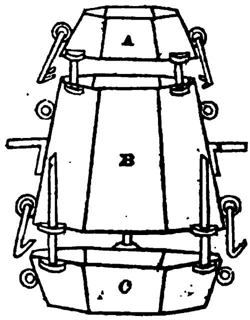
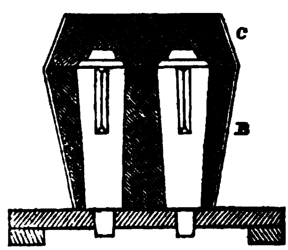
thickness of sand is rapped to form the grease-chamber in the bush. This part is made of sand, so as to be separable, and thus allow the core-pin to be driven out of the bush when cast.

The box in which the bushes are cast consists, as already mentioned, of three parts. The length of the middle part is made the same as that of the bushes between the small end and the tops of the feathers. The parts are octagonal in plan, as represented in the annexed figure. A the top, B the middle, C the bottom.



In proceeding to mould the pattern, a flat board is laid down level, with two holes in it at a suitable distance from each other. Upon this board a pair of bush-patterns are set down on their small ends, the points passing through the holes in the board, to keep the pattern steady. The box B, is inverted and laid down over them, and filled with sand, which is rammed about the patterns level with the tops of the feathers on them. The box C, is now fixed on and rammed with sand. The figure annexed is a sectional view of the boxes and their contents at this stage of the process.



The two boxes together are inverted and set down—the box A, is fixed on the uncovered end of B, and it likewise is rammed flush with sand. Two holes are next pierced downwards in the sand, with the handle of the rammer, one to each side of the patterns. One of them extends just through the box A, the other reaches down to the box C. A and B, together, are lifted off C, and turned over, the patterns, loosened by tapping, are next drawn out. A and B are then separated. Two prepared core-pins are next set, as vertically as possible, into the recesses left by the prints in the sand of the lowest box; on the surface of the sand at each end of the box B, channels are cut joining the gate-holes, made by the rammer, to the two mouldings, in such a manner as that the short gate will be connected with the upper end, and the long gate with the under end of the mouldings. B is lowered over the cores, and fixed to C, being directed by the long guide pins at the side. A is next replaced, guided also by pins, and fixed to B. It must be placed with care, as the upper ends of the cores are at the same time entering the recesses made by the prints. And thus the cores are secured between the boxes A and C.

The moulding, as thus finished, is shown in fig. A, which is an external view of the whole, with the interior arrangement in dotted lines. Fig. B, is a view of the upper and under ends of the middle

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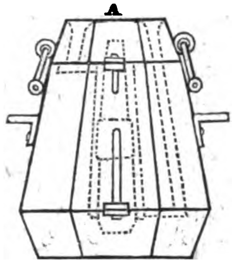
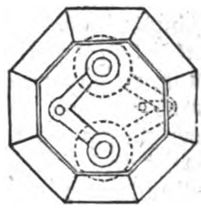
box, showing the gate channels. The iron is poured into the long gate, falling against the bottom of it, the force of the iron is broken, and it runs gently into the mouldings, rising within them till they are filled, when it passes into the short-flow gate, as it is termed; from which it issues, carrying off the refuse it may have gathered in its passage. Blackening is not applied to these moulds, as their roughness is of no consequence.

A



B



SECTION II.—Having in the first paper on this peculiar art, given two detailed examples of the mode of moulding and casting light, flat ware, illustrating, generally, the manner of conducting the manufacture of these goods; the practice of hollow moulding falls now to be described, as that branch of moulding naturally precedes in order of description, the heavier species of green-sand moulding.

The distinct objects of hollow moulding are comparatively few in number, and small in dimension; there are moulding boxes for them individually of corresponding shape, generally manageable by one person. Boxes in two, three, or four parts, are employed as the necessities of the case may require. We shall select, for example, the moulding of an Irish pot, of which the annexed is a sketch. The body of it is nearly spherical, drawn in at the neck, and opening towards the brim. It has two ears at the neck, by which it is moved about when in use, and three feet on the bottom. The pattern is an exact model of the pot, being in two halves separating vertically. The patterns of the feet and ears are also loose on the body of the pattern, fitting to it by pins. To form an original pattern, the method usually adopted is that of moulding in loam, which will be understood afterwards, when we come to describe this branch of the art. In the mean time, it is sufficient to state, that the rough cast pattern is chucked in the turning lathe, and turned within and without to the required form and thickness, in doing which, it is facilitated by boring four longitudinal rows of small holes through the pattern at equal distances round it, by which its thickness at any part may always be ascertained. Having been smoothed and polished, the pattern is taken from the chuck, and cut in two equal parts, in which holes are bored at the proper positions for receiving the pins of the ears and feet.

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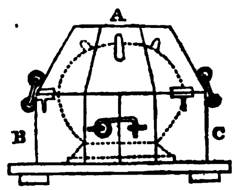
The pattern is moulded in a box, consisting of four parts, named the top, marked A in the ensuing figures, the two cheeks, B, C, and the bottom, D; the division into parts is similar to that of the moulding box for axle bushes described in the preceding paper, supposing the middle part divided vertically in two, corresponding with the cheeks, B, C. The pattern being moulded in an inverted position, the top, A, is made to inclose the bottom of the pot, as far up as its largest diameter; the cheeks, B and C, inclose the remaining portion of the pot, and the bottom, D, serves to close up the mouth of it.

The two cheeks are first of all laid down on a level board and linked together; the pattern is then laid down on its brim within the cheeks, being raised off the board by a slip of wood, of which the thickness is adapted to bring the largest diameter of the pot to the level of the upper edges of the cheeks. The patterns of the ears are attached, and sand is rammed in round the pattern flush with the cheeks, making the parting surface on the centre of the pot. The surface having been sprinkled with parting sand, the top, A, is put on, led into its place by guide pins, and fastened to the cheeks. Sand is again rammed into the level of the mouth of the box, the patterns of the feet and the gate pin being set in their places in the course of the ramming of the sand. The annexed fig. shows the position of things as now described. The whole is next inverted, and the board and slip of wood removed. The surface of the sand round the brim of the pattern is smoothly sloped off to the edge of the box, forming the parting surface, and the bottom, D, is fixed on. It is also filled with sand. The body, or core, of sand filling the interior of the pattern, is pierced in several places with a pricker sent down to the pattern, forming thereby channels of escape for the air expelled by the metal introduced. The whole is finally re-inverted, D lying undermost, and placed on a flat board with a hole in it to allow the escape of the air. The sand outside the pattern is sometimes pricked, though this is but of little importance.



The part A is now separated and lifted off, carrying the feet and the pin with it. The cheeks, B, C, are next separated horizontally, taking the ears with them; and the half patterns are withdrawn from the core. The external and internal moulds, thus exposed, are sleeked up with appropriate tools, and blackening is dusted on them, and also sleeked up. The patterns of the feet and ears, and the gate pin are drawn out, the boxes, B, C, are replaced exactly as before, and the box A, above them, the whole being again bound together. The mouth of the gate is next formed and smoothed. The space occupied by the pattern is now vacant for the metal. This is an external view and section of the box and moulding. In the section are shown the parting surfaces, and the slope of the under one.

All dished utensils are cast with their mouths downwards, and in some cases, the area of the mouth is so small, compared with the

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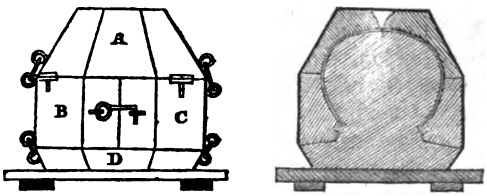
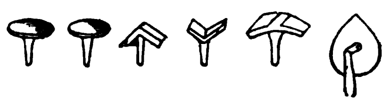


largest diameter, as to render it necessary to bind down the core in the mouldings; for it is very evident that the iron lying so far in below the core, tends, by its upward pressure, to lift the core off from its base. Such a result would, of course, spoil the casting. This binding is requisite in kettle mouldings in particular. It is simply effected by burying an iron rod in the core, having on it a cross at the end to give it a hold of the sand, the outer end being locked to a transverse piece which bears on the edges of the box.

The metal requires to be at a high temperature for hollow moulding; for so quickly does it cool, that the brim of a moderately sized pot *sets* even before the mould is filled. While yet red hot, the casting is taken out of the sand, and the gate piece knocked off. This must be done at a certain stage of the cooling, as when too soon done, the gate does not break clearly off; and when delayed too long, it often carries out a piece of the bottom of the pot with it. With a view so far to provide against this, the pot is made considerably thicker at the centre of the bottom. Flat gates are formed for flat bottomed ware—frying pans, for example. They are wide at the mouth to receive the iron the better, but taper like a wedge, towards the moulding, so as to be easily separated from the casting. By being of considerable extent, flat gates conduct the metal more speedily to the different parts of the mould.

1 2 3 4 5 6



Here are represented the forms of the cast-iron sleekers, employed in the operations of hollow moulding. Nos. 1 and 2, show the convex and concave sleekers for corresponding surfaces. Nos. 3 and 4, are tools with double plane surfaces, at certain angles with each other. Of these there is a variety, having their planes at different angles to suit the various salient and retreating angles that occur in mouldings. No. 5, is a sleeker for the impressions of beads; and No. 6 serves to smooth flat surfaces generally. All these have small studs attached to them which serve for handles.

(To be continued.)

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direct from the Ore; as practiced at the Shirva Works, Kirkintillock, Scotland. By William Neale Clay.

In this communication, the author first describes the various stages through which the metal passes, between the reduction of the ore, and its arriving at the state of malleable iron, by the ordinary mode of manufacture; and then he explains the process which he has invented, and introduced practically at the Shirva Works.

By the ordinary system of iron-making, the ores are reduced into the state of carburet of iron, and then, by refining and puddling, the metal is de-carburetted, thus making it into malleable iron by a number of processes, which are recapitulated:—

1st. Calcining the ore.

2nd. Smelting in a furnace, by the aid of blast, either cold or heated, with raw coal, or coke, for fuel, and limestone as a flux.

3rd. Refining the "pig" into "plate" iron.

4th. Puddling, shingling, and rolling, to produce the "rough," "puddled," or No. 1 bars.

5th. Cutting up, piling, and rolling, to produce "merchant," or No. 2 bars.

6th. A repetition of the same process, to make "best," or No. 3 bars.

Seeking to diminish the number of manipulations, by the new process a mixture of dry Ulverstone, or other rich iron ore, (Hæmatite) is ground with about four-tenths of its weight of small coal, so as to pass through a screen of one-eighth of an inch mesh. This mixture is placed in a hopper, fixed over a preparatory bed, or oven, attached to a puddling furnace of the ordinary form. While one charge is being worked and balled, another gradually falls from the hopper, through the crown, upon the preparatory bed, and becomes thoroughly and uniformly heated; the carburetted hydrogen and carbon of the coal, combining with the oxygen of the ore, advances the decomposition of the mineral, while by the combustion of these gases, the puddling furnace is prevented from being injuriously cooled. One charge being withdrawn, another is brought forward, and in about an hour and a half, the iron is balled, and ready for shingling and rolling. The cinder produced, is superior in quality to that which results from the common system; it contains from 50 to 55 per cent. of iron, and is free from phosphoric acid, which frequently exists, and is so injurious, in all the ordinary slags: when re-smelted, it produces as much No. 1 and No. 2 cast-iron, and of as good quality, as the ordinary "black band" ore of Scotland. The cast-iron produced from the slag (amounting to one-third of what was originally contained in the ore), is mixed with the ore and coal in the puddling furnace; and thus, while nearly all the iron is extracted from the ore, as much wrought iron is produced in a given time, and at the same cost of fuel, as by the old system. The first process, producing puddled bars of superior quality, is, consequently, on a par with the fourth stage of

the old system, as it avoids the necessity of the preceding separate manipulations. From the absence of all deleterious mixture, by once piling and re-heating the rough bars, iron is produced, of a quality in every respect equal, and in powers of tension, superior, to that which results from the second piling and reheating in the common mode; it is, therefore, contended that the two processes produce from the hæmatite nearly one-third more iron, of as good a quality as is usually obtained by the six processes of the old system. The iron thus produced bears a high polish, is very uniform in its texture, is ductile and fibrous, having more than an average amount of tensile strength, and at the same time appears to be more dense, as it possesses a peculiar sonorousness, resembling that of a bar of steel when struck. It has also been converted into steel of a good quality.

The paper is illustrated by a drawing of the furnace necessary for the process, and by specimens of the iron and steel produced.

Remarks.—Mr. Clay contended that the ordinary method of making iron was neither so scientific, nor so practically good as there was reason to expect it would have been, when iron formed so considerable an item in the productive industry of the country. His invention was in some degree based upon the old Catalan fire, wherein malleable iron was produced direct from the ore, although by a considerable expenditure of fuel: by his process the ore was also reduced at one operation into the state of malleable iron, by combination with a large portion of carbonaceous matter; and as the deoxidation of the ore could proceed simultaneously in an adjoining preparatory bed, through which the flame of the puddling furnace traversed, there was necessarily a great saving of time, labor, and fuel in the production of the metal, while the quality was at the same time improved. He argued, therefore, that if the system was generally adopted, a large portion of the capital now sunk in the expensive constructions of blast furnaces, blowing engines, &c., would be dispensed with.

Mr. Taylor observed that the process appeared to be only applicable to the rich qualities of iron ore, which were now used in comparatively small quantities, as a mixture with the clay iron stones of the coal fields, from which iron was generally produced in this country. There existed large quantities of hæmatite in Great Britain, equal in quality to that of Nassau, or of the Hartz mountains, from which so much iron was made, for converting into steel. The mines of Ulverstone alone now produce 50,000 tons annually, and at least 25,000 tons more could be shipped from Cornwall; and if a demand existed, there was scarcely a limit to the quantity that could be raised. He apprehended that the iron made by this process could be converted into good steel: this was very desirable, as it would render this country independent of Sweden and Russia, whence nearly all the steel-iron was now imported.

Mr. Heath had examined Mr. Clay's process of iron making, and found that the wrought iron produced from a mixture of Scottish pig-iron, and hæmatite ore, was of a superior quality, bearing severe tests without injury. The iron made by this method, from India pig-iron and specular iron ore (per-oxyde of iron) from Devonshire, which was

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sessed the quality of welding like shear steel, without any of its defects. The method he alluded to, was to combine manganese with the cast steel in the crucible, and when drawn out under the tilt hammer it could be worked and welded to iron, like shear steal: the consequence of this discovery was, that the latter quality of steel was almost abandoned for cutlery, and the former was now generally used, as it did not exhibit the laminated appearance when polished, which shear steel frequently did. The metal was sounder, and fewer wasters were made. All the brown hæmatites contained manganese, and there was little doubt that, by selecting the proper kinds of ore, malleable iron might be made in Great Britain by this process, as good for converting into steel as any of the Swedish iron. There was abundance of specular iron ore on Dartmoor, equal to the Elba ore, and which would (he had little doubt) produce as good iron as that from the Dannemora ore.

Dr. Faraday remarked that the process invented by Mr. Clay was founded on sound chemical principles. It was desirable to abandon the use of limestone as a flux: it was proved that the purest limestones contained phosphates, which, although advantageous in agricultural processes, were detrimental in iron making.

Mr. Fox had tried some specimens of Mr. Clay's iron, and found them to bear severe tests, as well as the best cable bolt iron made in the ordinary manner.

Mr. Clay explained that Mr. Heath's process was not indispensable for converting into steel the iron made by his method; and also that argillaceous iron ores, after calcination, could be treated in his furnace, like the hæmatite ores, but not so advantageously.

Mr. Taylor said that 25,000 tons of steel were converted annually in this country, and of that quantity not more than 2500 tons were made from the best Swedish iron; for the remainder, inferior qualities of iron, such as Russian iron, marked CCND, from the forges of Monsieur Demidoff, were used. All that iron was made with charcoal, and could only be called inferior, when compared with that made from the Dannemora ore. If Mr. Clay's process was successful in treating the hæmatite ores, as had been stated, it was of great importance, as it would emancipate the country from a dependence upon foreign products. He had recently seen in Germany, a process of producing steel by stopping the operation of puddling pig-iron at a certain point, or intermediate state between cast and wrought iron, and hammering the mass at once into bars. The operation was one of much delicacy, and depended entirely upon the skill of the workman.

Mr. Heath believed the manufacture of steel was involved in unnecessary mystery; it was the general opinion that foreign iron was essential to produce good qualities. Iron as now made from coke furnaces, certainly contained too much foreign matter to be used for steel, and it would require more attention to the selection of the materials, before pure iron could be obtained; some of the Low Moor

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iron, the good quality of which was universally admitted, had been made into blistered steel, but although the springs made with it appeared perfect, it was said that they did not answer so well as those made with steel from charcoal iron. The Sheffield manufacturers required that steel should possess "nature and body;" the first quality to enable it to be rolled and drawn out without cracking, and the second, that it might receive and retain a fine edge. Steel made from Garnderris iron (South Wales) possessed "nature," but if made into cast-steel, it fled into pieces in working, as it did not possess "body." Steel from German ores appeared to have "body," but wanted "nature." Steel from Indian iron, although difficult to work, stood better than other kinds when once reduced into form; this he attributed to the purity of the magnetic ore from which it was produced; there was not the slightest trace of phosphorus, arsenic, or any deleterious foreign matter. He was convinced that, with a mixture of Indian pig-iron (which could be produced very cheaply) and Devonshire ore, by Mr. Clay's process, iron could be made of excellent quality for converting into steel at such a reduced price, as would render the introduction of Swedish and other foreign iron unnecessary.

Mr. Taylor believed that improvements in the quality of steel, rather than reduction in the price, was the object sought. In the large quantity used in the mines under his direction, the dearest steel was found to be the more economical. He had seen as many as 12 dozen borers used to make one blast hole, and unless the tools kept their points well, the labor of the men was thrown away.

Civ. Eng. & Arch. Journ.

On the Perfect Ventilation of Lamp Burners.

In consequence of the injury sustained by the books in the library at the Athenæum Club, amounting almost to the entire destruction of the bindings; and the complaints of the members of the vitiated state of the air in the rooms, causing headache, oppressive breathing, and other unpleasant sensations; Professor Faraday's attention as a member of the club, was drawn to the subject of ventilating lamp burners in houses; and he was induced to suggest the trial of various plans, for affecting the removal of the products of combustion, produced by sources of artificial light. All substances used for the purpose of illumination, may be represented by oil and coal gas; although tallow and wax are also greatly employed, yet as until they are rendered fluid like oil, they cannot be burnt, they may for all practicable purposes be classed with it. Now, oil and gas both contain carbon and hydrogen, and it is by the combination of these elements with the oxygen of the air, that the light is evolved. The carbon produces carbonic acid, which is deleterious in its nature, and oppressive in its action in closed apartments, and the hydrogen produces water. A pound of oil contains about 0.12 of a pound of hydrogen, 0.78 of carbon, and 0.1 of oxygen; when burnt it produces 1.06 of water, and 2.86 of carbonic acid, and the oxygen it takes from the atmosphere is

equal to that contained in 13.27 cubic feet of air. A pound of London coal gas contains, on an average, 0.3 of hydrogen, and 0.7 of carbon; produces when burnt, 2.7 of water, and 2.56 of carbonic acid gas; consumes 4.26 cubic feet of oxygen, equal to the quantity contained in 19.3 cubical feet of air. So a pint of oil, when burnt, produces a pint and a quarter of water; and a pound of gas produces above 2½ pounds of water; the increase of weight being due to the absorption of oxygen from the atmosphere, one part of hydrogen taking eight by weight of oxygen, to form water. A London Argand gas lamp, in a closed shop window, will produce in four hours, two pints and a half of water, to condense or not, upon the glass or the goods, as it may according to other circumstances happen; also, a pound of oil produces nearly three pounds of carbonic acid, and a pound of gas, two and a half pounds of carbonic acid. Now, carbonic acid is a deadly poison, an atmosphere containing even one-tenth of it, is soon fatal to animal life. The various accidents from lime and brick kilns, from brewers' vats, occasionally from the sinking of wells, as at Cheltenham, and from the choke damp in coal mines, attest the extreme danger contingent upon the presence of this substance. A man breathing in an atmosphere containing 7 or 8 parts of carbonic acid, would suffer, not from any deficiency in oxygen, but from the deleterious action of the carbonic acid. M. Leblanc has recently analyzed carefully the confined air of inhabited places, and concludes, as stated in his *Memoire*, that the proportion of carbonic acid gas in such places, may be regarded as measuring with sufficient exactness, the insalubrity of the air; that in the proportion of one part to a hundred of air, ventilation is indispensable for the prevention of injury to the health; that the proportion of carbonic acid gas had better not exceed a five hundredth part, though it may rise without inconvenience, to a two-hundredth part. If a lighted taper be applied to the top of a lamp chimney, it will be instantly extinguished, or a glass jar held over it will become immediately filled with air, in which a light cannot burn. Also sulphurous and sulphuric acid, are contained in the water which results from the combustion of coal gas, and are products injurious to metals and articles of furniture.

It will now be understood, that the object sought to be obtained in the ventilation of lamp burners, is the entire removal of all the noxious products of combustion. And with this view, at Professor Farraday's suggestion, the gas lights of the chandelier in the library of the Athenæum, were ventilated by pipes dipping into the lamp glasses, and conjoining at a short distance upwards into one central pipe, which carried away all the burnt air out of the room. In this first practical experiment, many things were learned as to the mode of arranging the pipes; the disposal, when the pipes were very long, of the water produced, &c.; but the objects sought for by the ventilation, were at once and perfectly obtained. This principle may be illustrated by a simple experiment, showing the difference between allowing combustion to give its products to the air of a room, and carrying off these products as soon as formed to the exterior; let a short wax candle be placed burning on a plate, a glass jar put over it, and the upper aper-

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ture of the jar closed by a globular cork, through which passes a piece of glass tube, about half an inch in diameter, and twelve or fourteen inches long; the tube descending to the top of the candle flame, and being placed just above it. Under these circumstances there will be plenty of air passing into the jar, between it and the plate, and out by the tube, to supply all that is needed for combustion, and keep the glass chamber sweet; the consequence is, that in this position it will go on burning for any length of time, and the jar remain quite clear and bright; but on moving the cork a little, so that the tube shall no longer be over the flame, all these results will change, though the air-way remains exactly as before. The candle will now give the products of its combustion to the general air of the glass chamber, the glass will immediately become dull, from water deposited upon it, the air itself will become worse and worse; the light become dim, and in a few minutes will go out. But if arrested from doing so by the tube being again placed over it, signs of recovering will appear, the light will return to its former brightness, and after a short time, even the dew will disappear from the glass; all in consequence of the proper ventilation of the light. These effects, though striking, may easily be understood by any one who will think of the difference of lighting a fire in the middle of a room, instead of under, or in right juxtaposition to a chimney.

Then came the desire of modifying the system, by removing the ascending flue from its place over the lamp, not from any deficiency in action, but for appearance sake only; and finding that there was sufficient ascension power in the main part of the metal chimney, to allow of a descending draught over the lamp, the tube, in place of going directly upwards, was made to turn short over the edge of the glass, to descend to the area or bracket, to pass along it, and then ascend at the central part of the chandelier, or against the wall if applied to a single light. To this succeeded another form, which is exceedingly beautiful, and appears to be the perfection of lamp ventilation. It is, in fact, a beautiful application of the principle of a descending draught to a lamp burner. The gas light has its glass chimney as usual, but the glass holder is so constructed as to sustain not merely the chimney, but an outer cylinder of glass, larger and taller than the first; the glass holder has an aperture in it, connected by a mouth-piece with a metal tube, which serves as a ventilating flue, and which, after passing horizontally to the centre of the chandelier, there ascends to produce draughts, and carry off the burnt air.

The burnt air and results of combustion, take the course indicated by the arrows, and are entirely carried away by the chimney. Now with a lamp burning in the ordinary way, the products of combustion issue out as a torrent of ærial impurity from above, but if the above arrangement be applied, on closing the top of the outer glass cylinder by a plate of mica, all the soot, water, carbonic acid, sulphurous and sulphuric acid, and a portion of the heat, are entirely carried away by the ærial sewerage, and discharged into a chimney, or the open air, and the air in rooms may thus be kept in the same sweet and whole-

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some condition, and fit for the purposes of respiration, as if artificial light were not being used.

Fig. 1.—*a*, is the burner; *b*, the gas pipe leading to the burner; *c*, the glass holder, with an aperture in it opening into the mouth-piece *d*, which is attached to the metal chimney, *i*; *e*, the ordinary glass chimney; *f*, an outer cylinder of glass closed at the top by a plate of mica, *g*, or still better, by two plates of mica, one resting on the top of the glass, and the other one, *h*, dropping a short way into it; they are connected together by a metal screw and nut, which also keeps them a little apart from each other, thus forming a stopper which cannot be shaken off the glass chimney, but is easily lifted on and off by the small metal ring or knob at the top; *i*, is the metallic tube chimney; *k*, a ground globe, which may be applied to the lamp, and which has no opening except the hole at the bottom, where it rests on the glass holder; but any other form, as a lotus glass, or a vase, may be substituted at pleasure.

Fig. 1. Fig 2.

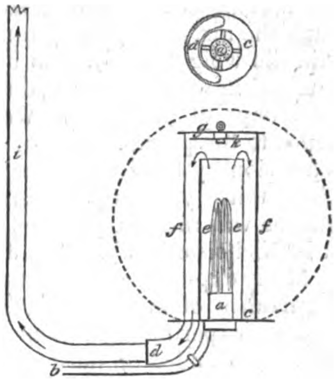

Fig. 2, is a plan of the glass holder, showing the burner, *a*, in the centre, perforated with jets, with openings round it to allow of a free admission of air to the flame, and the aperture *d*, which opens into the mouth-piece, connected with the metal chimney, *i*.

A curious but important result of the inclosed lamp, is the increase of light produced, amounting to from 10 to 20 per cent., according to circumstances, the same quantity of gas being consumed as before. If the current of air through a lamp glass, when the gas is burning in the usual manner, be diminished, the flame rises in height, and the light is increased in amount, but is of a redder color; the combustion in fact is not so intense, because the access of air is retarded; the particles of carbon which give the light, are not so highly ignited, but are more abundant, and are ignited for a *longer time*, thereby causing an increase of light.

The advantages of the above plan are many; it is not in the least objectional in architectural appearance, the ventilation is perfect, the heat given to a room is modified and pleasant, and may be either sustained or diminished at pleasure; the light, for good philosophical reasons, is increased considerably for a given portion of gas, and increased safety from accidents is obtained; as in the event of any leakage from the pipes, or from a gas cock being inadvertently left open, the gas, instead of mixing with the air of the room, and becoming explosive, would be almost inevitably carried off by the metal tubes.

We understand that Prof. Faraday has transferred his right to this invention, to his brother, a gas-fitter, who has secured it by a patent.

Civ. Eng. & Arch. Journ.

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Retrospect of the Progress of Aerial Navigation, and Demonstration of the Principles by which it must be governed. By Sir GEORGE CAYLEY, Bart.

Sir,—Within the last six months there has been considerable excitement evinced, respecting a scheme for transporting men and goods through the air, by mechanical means, without the aid of balloons to sustain the weight intended to be thus conveyed. The proposal was announced in so decided a manner, and in such startling terms, that in these days of mechanical wonders, some are disposed to give full credence to the practicability of the undertaking, and others to reject it as a visionary hoax on public credulity.

About thirty years ago, the subject of ærial navigation by mechanical means was much canvassed, and several papers were published on it in Nicholson's Chemical Journal, the Philosophical Magazine, &c. Many experiments, as to the means of support, and the stability and guidance of such machines, were then made on a large scale, some of the experimental vehicles having from three to four hundred feet of canvas, extended on masts, and braced by rigging, to give strength and precision of position to their surfaces. These trials proved in the most decided manner, that perfect stability and guidance were effected, and that the means of support, to a certain limited extent, were attainable. For instance, it was proved that a man placing himself in a machine of proper dimensions for his weight at the top of a mountain, say one mile above the level of the plain below, might, in calm weather, with steadiness and security proceed through the air to any place to which he might choose to steer himself, about eight miles in horizontal measure from the point of his departure. Of course, in this case the line of flight must be in a continued descent of one in eight, and gravitation is the only cause of the progress of the machine; the case, being, in some measure, similar to that of a carriage running down hill without horses. If, instead of this machine being allowed to descend in its path by gravity alone, the man had applied his power to propel it, by revolving oblique fliers, or other suitable means of waftage, he might probably have extended the distance from eight to twelve or fifteen miles; but the muscular strength of a man is not sufficient to maintain a horizontal path, unless it be for a very short time.*

To render ærial navigation by mechanical means alone, efficient, some first mover is required, which combines great force with little weight. The steam engine, in any of those permanent forms, calculated for real service, together with the water and fuel it requires, would probably be found inconveniently heavy for the purpose, if not

* Many years ago, Mr. Degen, who was a prisoner at Vienna, by means of large surfaces formed like umbrellas, succeeded in elevating himself fifty feet, as measured by a cord which was attached to his machine by the goaler for safe custody, but at the expense of the total exhaustion of his muscular strength in a couple of minutes. A man, when running up stairs for a few seconds, is exerting the ordinary power of two horses—being twelve times greater than the power he can use with permanent effect.

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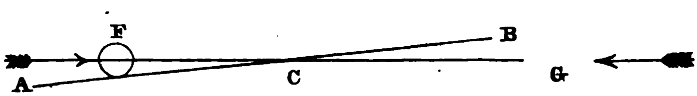
the date I have alluded to, operated as a check to future inquiry on the subject. When, however, a lighter first mover should be invented, every other part of the apparatus was in readiness to meet the discovery, and realize the scheme.

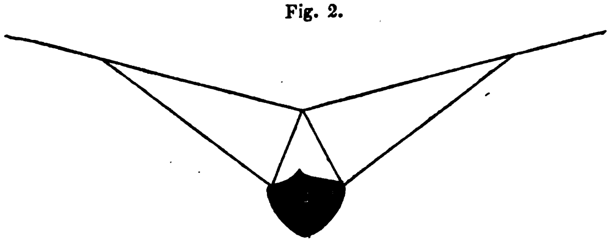
As the principles of ærial navigation, by mechanical means, are few and simple, a recapitulation of them at the present moment may not be unacceptable to your readers, and may enable them to judge more correctly of the project I have alluded to, when more distinctly presented to the public.

Fig. 1.



The leading principle of ærial navigation, is that of the inclined plane. Suppose A B, fig. 1, to represent an inclined plane, rising one foot in ten; it is well known that if the ball F, weighs 100 lbs., a force of 10 lbs., applied horizontally, would sustain it from rolling back. Conceive the same line A B, to represent, also, the section of a large surface, like the sail of a ship, and that C G represents a cord by which it is sustained from being driven back by a horizontal wind blowing in the adverse direction. If the sail contains 100 square feet of surface, and the wind has sufficient power to press with one pound to the foot, 100 pounds weight will be supported, and the tension on the cord will be only 10 lbs. It is the same thing whether the wind thus blows against the sail, or the sail be driven, with equal velocity, horizontally in calm air; the 10 lbs. propelling power, will still sustain the 100 lbs. in the air. It is difficult to ascertain the precise angle used in the wings of birds; but one in ten certainly exceeds that of most birds, and probably one in sixteen is nearer the truth.

Fig. 2.



The stability of these machines is maintained laterally, by making

* The water used in the high pressure tubular boilers, amounts to about 70 pounds per horse power per hour, the fuel about 10, so that the food of the steam horse is about 80 per hour. The engine itself, if of the lightest efficient structure, may weigh about 150 lbs. to the horse power. If the steam were condensed again, by exposure within extended surfaces to the cooling influences of the current of air, no larger supply of water would be required; but such extended surfaces are inconvenient, and add greatly to the weight.

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the surface in its cross section, as represented in fig. 2. By this means, the side that comes down in any heel of the vehicle, meets a *greater* resistance, whereas, that which has necessarily gone up, meets with *less*, and this contrary action, operating on a large extent of leverage from the centre, immediately restores the proper position. The distance of the centre of gravity G, below the centre of support, also tends greatly to increase this power, and mainly contributes to the stability of the machine in the line of its path. This, however, is also aided by the adaptation of a horizontal rudder, like the fan tail of birds, used for the purpose.

The side guidance is perfectly effected by a rudder in a vertical plane, as in the case of ships, and elevation and descent are produced, in ordinary cases, by having the command of the horizontal rudder already noticed; but when progressive motion is not required, and the ascent or descent is to be made perpendicularly, then the effect is produced by the power being applied to extensive oblique vanes, or fliers, which, when not employed in this way, are so made as to become flat, and thus form the surfaces already described. The progressive impulse is most readily obtained by smaller oblique vanes, like the screw propellers in boats, worked by the power of whatever engine is employed; or the oblique wing waftage, as is used by birds, may be employed.

The real question rests now, as it did before, on the possibility of providing a sufficient power with the requisite lightness. I have tried many different engines as first movers, expressly for this purpose. Gunpowder is too dangerous, but would, at considerable expense, effect the purpose; but who would take the double risk of breaking their necks, or being blown to atoms? Sir Humphrey Davy's plan of using solid carbonic acid, when again expanded by heat, proved a failure in the hands of our most ingenious engineer, Sir M. Isambard Brunel.

As all these processes require nearly the same quantity of caloric to generate the same degree of power, I have for some time turned my own attention to the use, as a power, of common atmospheric air expanded by heat, and with considerable success. A five-horse engine of this sort was shown at work to Mr. Babbage, Mr. Rennie, and many other persons capable of testing its efficiency, about three years ago. The engine was only an experimental one, and had some defects, but each horse power was steadily obtained by the combustion of about 6½ pounds of coke per hour, and this was the whole consumption of the engine, no water being required. Another engine of this kind, calculated to avoid the defects of the former one, is now constructing, and may possibly come in aid of balloon navigation—for which it was chiefly designed—or of the present project, if no better means be at hand.

London, March 25. Mechanics' Magazine.

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After a long trial of ten days, unprecedented, we believe, in the annals of the Jury Court of Scotland, a verdict was returned in favor of the pursuers, at six o'clock on Saturday evening, the particulars of which will be found subjoined. The following is a copy of the issues:—

Issues in the Cause in which James Beaumont Neilson, of Glasgow, engineer, Charles M'Intosh, formerly of Crossbasket, now of Campsie, John Wilson, formerly manager of the Clyde Iron Works, now of Dundyvan, for themselves; and James Oswald, of Shieldeall, now one of the members of Parliament for the city of Glasgow, James Dunlop, jr., merchant in London, brother-german of Colin Dunlop, after designed, Andrew Bannatyne, writer in Glasgow, Charles M'Intosh, aforesaid, James Dunlop, formerly of Fludyer street, Westminster, now residing at Clyde Iron Works, nephew of the said Colin Dunlop, and John Wilson, aforesaid, as trust-disponees of Colin Dunlop, formerly of Clyde Iron Works, thereafter of Tolcross, now deceased, conform to his trust-disposition, and deed of settlement in their favor, dated the 29th day of January, in the year 1834, and two codicils thereto, dated respectively the 29th day of June, 1836, and 29th day of May, 1837, which trust-disposition and codicils are all recorded in the Sheriff Court books of Lanarkshire, the 27th day of September, 1837, as also executors *nominate* of the said Colin Dunlop, conform to confirmed testament in their favor, expede before the Commissary of the Commissariot of Lanarkshire, of date the 18th day of April, 1838—are *pursuers*;—and

Messrs. William Baird, Alexander Baird, James Baird, Douglas Baird, and George Baird, carrying on business in partnership at Gartsherry Iron Works, in the parish of Old Monkland, under the firm of William Baird and Company—are *defenders*.

It being admitted that, on the 1st day of October, 1828, the pursuer, James Beaumont Neilson, obtained letters patent under the Great Seal used in Scotland, in place of the Great Seal thereof, and duly enrolled a specification, in terms of the proviso contained in the said letters-patent, being Nos. 30 and 31 of process;

It being also admitted that the pursuers, other than the said James Beaumont Neilson, have acquired, by assignment from him, a joint interest in the said patent;

Whether, in the course of the year 1840, and between the 27th day of March, and the 7th day of May, in the said year, and during the currency of the said letters-patent, the defenders did, in, or at their iron works at Gartsherry, by themselves, or others, wrongfully, and in contravention of the privileges conferred by the said letters-patent, use machinery, or apparatus, substantially the same with the machinery, or apparatus, described in the said specification, and to the effect set forth in the said letters-patent and specification, to the loss, injury, and damage of the pursuers?

Or,—1. Whether the invention, as described in the said letters-

patent and specification, is not the original invention of the pursuer, the said James Beaumont Neilson?

2. Whether the description contained in the said specification is not such as to enable workmen, of ordinary skill, to make machinery, or apparatus, capable of producing the effect set forth in the said letters-patent and specification?

3. Whether machinery or apparatus, constructed according to the description in the said letters-patent and specification, is not practically useful for the purposes set forth in the said letters-patent?

July 5, 1842. (Signed) D. Boyle, I. P. D.

The damages are laid as under—

Profits claimed, as at the date of action,	£10,000
Other damages, as at the same date,	10,000
Total damages laid,	£20,000

Edinburgh, March 4, 1843.

The Lords having heard counsel on the respective motions for the parties, ordain the minutes for the pursuers, dated 4th July, and 16th November, both last, Nos. 46 and 52 of process, to be engrossed on the issue in this case as relative thereto.

(Signed) D. Boyle, I. P. D.

July 4, 1842.—Rutherfurd, for the pursuers, stated to the court, he agreed that, under the first issue, it shall be competent to the defenders to try the issue of public use.

(Signed) And. Rutherfurd.

Nov. 16, 1842.—Rutherfurd, for the pursuers, agreed that it should be competent for the defenders, in the trial of the issues, as adjusted in this case, to state any objection, in point of law, to the validity of the patent, and relative specification, founded on the nature of the claim and statement there made on the part of the patentee, and that the court should decide the same, by way of direction, in the course of the trial. (Signed) And. Rutherfurd.

The case for the pursuers was opened before the Lord President, and a special jury, in the First Division of the Court of Sessions, on Wednesday, the 10th current.

The Lord Justice General and a special jury commenced, on Wednesday, the 10th of May, to try the above issues in this cause, which may be described as the most important of modern times in this country—whether we consider the vast interests at stake, or the great field of inquiry necessarily comprehended in testing the rights of the respective parties. In the words of the Lord Justice General, in addressing the jury, it was "an unparalleled trial—a trial which has embraced a more expensive body of evidence on both sides, and has occupied more of your attention, than any cause with which I am at all acquainted in this court." This trial occupied ten days, commencing, as we have stated, on Wednesday, May 10, and not terminating until Saturday, the 20th. The question regarded the validity of the patent obtained by Mr. Neilson, in October, 1828, "for the improved application of air, to produce heat in fires, forges, and furnaces, where

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Neilson proposed that the blast should be heated in its passage from the blowing apparatus to the furnace, and delivered hot, instead of cold, as formerly practiced. This was to be accomplished by placing one or more vessels, or air receptacles, between the blowing apparatus and the furnace, and heating those vessels externally in a considerable temperature. "It is better," says the patentee, in his specification, "that the temperature be kept to a red heat, or nearly so; but such a temperature is not absolutely necessary to produce a beneficial effect." When this invention was first made public, it was received with general distrust, and even ridicule; the prevailing, indeed, universal, opinion in the scientific world, and among the iron-masters, both in this country and abroad, having been, that the blast could not be too cold when it entered the furnace. This opinion was so far supported by the practical experience of the time, it having been remarked that the iron smelted better in winter than in summer. These prejudices were, however, dispelled as soon as Mr. Neilson's invention was seen in operation, and producing such prodigious results in the production of iron. Such was the power of hot-blast in the fusion of the materials in the furnace, that the product was doubled—*i. e.* a furnace produced as much in twelve hours with the hot-blast, as it had done in twenty-six hours with the cold. Talking generally, it was also found that this beneficial result was accomplished with one-half less fuel, and one-third less flux, or limestone. As regards Scotland, the great advantages of this invention were manifested in a remarkable degree. In 1828, or before the patent, the total quantity of iron produced in Scotland in one year, was about 60,000 tons; in 1840, the total quantity had risen to about 300,000 tons, being five times the product of 1828. This vast advance was mainly, if not exclusively, attributable to the hot-blast, which had entirely superseded the cold—not a single furnace in Scotland being worked, in 1840, or at the present time, by the cold-blast, with the exception of one at the Carron Works, and which is for their own exclusive use, the pig-iron produced thereby not entering the market. Another important illustration of the advantages of Mr. Neilson's invention, was its effect on the English iron market. In 1830, the total imported iron at Liverpool was 8980 tons, of which there was from Clyde, or Scotland, 3180 tons; in 1841, the total import at the same port was 37,304 tons, of which from Clyde, 30,899; in 1830, the total import of iron at Runcorn, (the other great emporium in England, of the iron trade,) was 3974 tons, of which from Clyde, there were only 11 tons; in 1841, the total import from Runcorn, was 18,161 tons, of which from Clyde, or Scotland, there were 14,306 tons—and every ton of which was, of course, manufactured by the hot-blast, there being then no cold-blast furnaces in operation in Scotland.

During the greater part of the currency of the patent, which lasted from October, 1828, to October, 1842, all the iron-masters in Scotland, and also those in England, who adopted the hot-blast, took out licences from the patentee, paying 1*s*, per ton, of iron smelted by them for the use of the invention. Latterly, however, the patent has been

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challenged, both in England and Scotland, and on various grounds. It was stated by the counsel of Mr. Neilson, at this trial, that he had as yet succeeded in establishing his patent, having triumphed in every instance, and obtained damages from the parties working the hot-blast without his license, and who were thereby declared to have wrongfully used his invention, or invaded his patent. In these actions, as in the present, against the Messrs. Baird, of Gartsherrie, the defences resolved into various allegation. It was argued at this trial, that the patent was void, as being only for a principle; or, in other words, it stated, in effect, that hot air was better for smelting iron than cold air, without fulfilling the conditions of the law, by clearly specifying the practical mode in which this was to be accomplished; that, in fact, the patent merely embodied a principle, without clothing that principle with any practical effect, in order to render the patent valid. Further, assuming that the specification did profess to set forth a practical mode of executing the invention, still the patent was alleged to be void, because this mode, if followed, would lead to a false, or impracticable, result. Then it was alleged that Mr. Neilson was not the original inventor, seeing that the hot-blast had been practiced at other places, and that it was publicly known previous to the date of the patent. This did not imply, and the Lord Advocate, as leading counsel for the Messrs. Baird, disclaimed the idea, that Mr. Neilson had borrowed the discovery from another, but, simply, that the invention might be original as regarded the merit of Mr. Neilson, but still not the subject of a patent, if it turned out that it had been previously known, and publicly used, or disclosed by others, though such prior discovery was totally unknown to Mr. Neilson. The validity was also challenged, in respect that the directions in the specification would not, as the law requires, enable workmen of ordinary skill in such matters, to construct an apparatus useful for the purposes set forth in the patent.

The Dean of the Faculty of Advocates, (Patrick Robertson, Esq.,) detailed the whole circumstances of the case, and the various proceedings in the Court of Session, and House of Lords. He contended for the validity of the pursurer's patent—he undertook to prove that the defenders, by themselves and others, had invaded, or taken advantage of, it, whereby they had made great gains, or profits, and that they were justly liable to make reparation to the pursuers. He concluded a brilliant speech, which occupied nearly six hours, by calling upon the jury to find accordingly.

Evidence was then led in support of the issues for the pursuers, which occupied the court from Wednesday till the Monday following. This evidence consisted of practical and scientific men from all parts of the kingdom. At its conclusion,

The Lord Advocate of Scotland, (Duncan M'Neill, Esq.,) opened the case for the defenders, in a masterly speech of five hours, in which he analyzed the evidence of the pursuers, and undertook to prove that the pursuer, Mr. Neilson, was entitled to no credit for his invention, because the hot-blast, for which he obtained the patent, was in use, and well known, before the date of it; that the patent itself was void

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in law, and that no damages were exigible by him, or by the pursuers, from the defenders. The evidence led by the defenders in support of the defence occupied the court from Tuesday till the afternoon of Friday.

A. Rutherfurd, Esq., (late Lord Advocate of Scotland,) then replied on the evidence, and on the whole case of the pursuers. His speech, which occupied four hours in the delivery, was clear, forcible, and lucid; he called upon the jury to protect his clients, whose legal and just rights had been invaded by the defenders amongst others, and to give exemplary damages under the issues.

The court then adjourned till the following day (Saturday).

The Lord President having resumed his seat on the bench, by half-past twelve o'clock, proceeded to charge the jury in a luminous, straightforward, and able manner. His Lordship's address occupied three hours and a half.

The Lord Advocate, on behalf of the defenders, having taken several exceptions to the views of the Lord President, the jury retired at half-past four, and, at six o'clock, returned, in effect, the following *Verdict*, unanimously finding in favor of the pursuers in all the issues: awarding 7000*l.* of damages, and 4867*l.* 16*s.* for profits—making in all, 11,867*l.* 16*s.* The 4867*l.* of profits being on 4392 tons manufactured within six weeks, the period specified in the present action.

Counsel for the Pursuers.—The Dean of Faculty (Patrick Robertson, Esq ,)Andrew Rutherfurd, Esq., (late Lord Advocate) the Solicitor-General, (Adam Aderson, Esq.,) and John Inglis, Esq., advocate. Edinburgh agents—G. and G. Dunlop, Esqs., W. S. Glasgow agents—Messrs. Bannatyne and Kirkwood.

Counsel for the Defenders.—The Lord Advocate, (Duncan M'-Neill, Esq.,) Robert Whigham, Esq., Charles Neaves, Esq., P. Mure M'Credie, Esq. Edinburgh agents—Messrs. MacAndrew. Glasgow agents—Messrs. A. and A. Graham.

London Mining Journal.

Steam-Boiler Explosions. By J. A. Haswell.

Sir,—Within the last six months there have been three boiler explosions of a serious nature, in this county (Durham). One of these took place last Thursday (December 29th), at the Patent Rope Manufactory of Messrs. Rowland, Webster & Sons, Deptford, near this town, and deserves especially to be recorded in your *Magazine.*

The loss of life, and the destruction of property, in this case, may not place it amongst the very worst of accidents, but the peculiar nature of the explosion gives it a claim on your attention; and with your permission I will briefly state the facts connected with it.

The engine is a high-pressure one of 30 horse-power, and was worked by two cylindrical boilers, each 23 feet long, 5 feet diameter, pressed at 35 lbs. on the square inch. The boilers were in a good state of repair before the explosion; in fact, they might be considered as new. They were so connected together, as to have the benefit of

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three safety-valves, to 3½ inches diameter, and one 4 inches diameter. The engine had been working all day at full work, and was to continue working until 10 o'clock at night; but at 6 o'clock the engineman was instructed to ease the engine, to enable the foreman to disconnect some of the machinery in the mill; when one of the boilers blew up with a tremendous crash, carrying away the roof of the apartment in which it was placed, and effecting other serious damage to the premises. Two of the workmen were much injured, and remain in a very precarious state; another person received a slight injury; and had it been a minute longer in occurring, there would have been not less than 20 men and women directly above the boiler, who would undoubtedly have lost their lives.

A few minutes after the explosion took place, the foreman, and engineer, (both practical men) and myself, examined the boiler, and found it torn across the middle, and longways towards the fire, on the bottom.

The boiler remained in its seat. A part was thrown up, and came in contact with a large T beam, 12 inches each way, and 1½ inch thick. This was broken into several pieces, which were thrown about in various directions. The force required to break the beam would be enormous, possibly sufficient to prevent the boiler from rising out of its place. The plates of the boiler were perfectly clean, but appeared to have been red-hot. The feed shut-off valve was quite shut, which would have prevented the water from going into the boiler, had the feed-pump been in a working state. There was no appearance of water about the building, except about a gallon in the other end of the boiler, which would accumulate from the stream rushing out of the boiler.

The opinion of several practical men, drawn from these facts, is that the explosion resulted from a deficiency of water in the boiler; and that the small portion left in it had been decomposed by the overheated plates, which had instantaneously generated *hydrogen* gas, possessing all the explosive force of gunpowder.

When we have before us such disastrous events as these, where so many lives, and such an amount of property, are depending on the attention of an individual, we ought to do all in our power towards hastening the time when our legislature will see the necessity of adopting a system of examination, which shall prevent engines and boilers being under the management of any but those "who are well trained, intelligent, and properly behaved, engineers—men who know something more about an engine, than to put on and off the steam."

Parliament has made some steps towards preventing inexperienced men taking charge of pit-engines; and surely if it be thought necessary to use caution in one case, we have an equal right to expect that those who may have charge of railway, steamboat, and factory engines, should be placed under the same restrictions, and not left to the care of men whose fitness for their task is left to be judged of by persons whose first consideration is the payment of the least amount of wages.

Pract. Mech. & Eng. Magazine.

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On the Electricity evolved by the Friction of Water and Steam against other bodies. By Michael Faraday, Esq.

The object of the experiments related in this paper, is to trace the source of the electricity which accompanies the issue of steam of high pressure, from the vessels in which it is contained. By means of a suitable apparatus, which the author describes and delineates, he found that electricity is never excited by the passage of pure steam, and is manifested only when water is at the same time present; and hence he concludes that it is altogether the effect of the friction of globules of water against the sides of the opening, or against the substances opposed to its passage, as the water is rapidly moved onwards by the current of steam. Accordingly, it was found to be increased in quantity, by increasing the pressure and impelling force of the steam. The immediate effect of this friction was, in all cases, to render the steam or water positive, and the solids, of whatever nature they might be, negative. In certain circumstances, however, as when a wire is placed in the current of steam at some distance from the orifice whence it has issued, the solid exhibits the positive electricity already acquired by the steam, and of which it is then merely the recipient and the conductor. In like manner, the results may be greatly modified by the shape, the nature, and the temperature of the passages through which the steam is forced. Heat, by preventing the condensation of the steam into water, likewise prevents the evolution of electricity, which again speedily appears by cooling the passages so as to restore the water which is necessary for the production of that effect. The phenomenon of the evolution of electricity in these circumstances, is dependent also on the quality of the fluid in motion, more especially in relation to its conducting power. Water will not excite electricity unless it be pure; the addition to it of any soluble salt or acid, even in minute quantity, is sufficient to destroy this property. The addition of oil of turpentine, on the other hand, occasions the devolopment of electricity of an opposite kind to that which is excited by water; and this the author explains by the particles, or minute globules, of the water having each received a coating of oil, in the form of a thin film, so that the friction takes place only between that external film and the solids, along the surface of which the globules are carried. A similar, but a more permanent, effect is produced by the presence of olive oil, which is not, like our turpentine, subject to rapid dissipation. Similar results were obtained when a stream of compressed air was substituted for steam in these experiments. When moisture was present, the solid exhibited negative, and the stream of air positive electricity; but when the air was perfectly dry, no electricity of any kind was apparent. The author concludes with an account of some experiments in which dry powders of various kinds were placed in the current of air; the results differed according to the nature of the substances employed, and other circumstances.

Lond. Athenæum.

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Notice of some New Methods of Gilding and Silvering by Immersion. By M. A. Levol.

At the present time, when great attention is being directed to the processes of gilding by the moist method, it seemed to me not without interest to publish an account of some new methods for gilding, or of silvering, by immersion, more especially on account of the facility of their execution.

Gilding on Silver.—Silver is very easily gilt by means of the neutral protochloride of gold, to which an aqueous solution of sulphocyanide of potassium has been added until the disappearance of the precipitate which at first formed. The liquor thus obtained should possess a slightly acid reaction, and if it has lost it, by too considerable an addition of sulphocyanide, it should be again restored by a few drops of hydrochloric acid. In order to gild, the well-cleansed silver is immersed in this liquor, nearly boiling, and moderately concentrated, in which state it is kept, adding from time to time, hot water to replace that which evaporates. In this manner the inconveniences which would result from too great an accumulation of the hydrochloric acid, the presence of which is nevertheless useful in preventing the formation of an auriferous precipitate, which would otherwise take place at the high temperature employed, were the alkali predominant, are obviated.

Gilding and Silvering on Copper, Brass, and Bronze.—A solution of cyanide of gold, and that of cyanide of silver in cyanide of potassium, has been recommended for gilding and silvering under the influence of electric forces. I have found that the same solutions, when at a temperature near their boiling point, may also be employed for gilding and silvering by immersion. Their preparation would be somewhat expensive were it necessary to obtain them chemically pure; but this would not offer the least advantage, and the operation may be simplified and rendered much less expensive by treating either the chloride of gold, or the nitrate of silver (both should be neutral) with an excess of cyanide of potassium, so as to obtain the soluble double cyanides.*

Silver cannot be gilt by this process, but it will be seen above that the sulphocyanide of gold, and of potassium, gilds this metal extremely well.

The solution of cyanide of copper in cyanide of potassium does not copper silver even in contact with zinc; but it coppers this last metal perfectly, and in a very solid manner.

I may observe, in conclusion, that these processes, so advantageous from their always succeeding, and requiring but a few minutes for every preparation, unfortunately do not allow but of the application

* As the cyanide of potassium is employed in a state of aqueous solution, and is very dear in the solid state, it is most advantageous to employ the mother-ley from the residue resulting from the calcination in a closed vessel of previously dried ferrocyanide of potassium. Its price then does not exceed a third of the commercial value of the double cyanide, and it might even be obtained at a still less price by the process indicated by Professor Liebig.

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common to all the processes by immersion.—*Journ. de Pharm. et de Chim.*, No. 3, March, 1842. Chem. Gazette.

Purification of Hydrochloric Acid of Commerce. By M. LAMBERT.

This process occasions little expense, and requires but little time, so that those manufacturers who may employ it, will be able to send into the market hydrochloric acid chemically pure, and costing scarcely a few farthings more a pound than the ordinary acid. When the acid to be purified contains sulphurous acid, which is the most usual case, I add a little binoxide of manganese, the oxygen of which converts the sulphurous into sulphuric acid. As, however, it is almost impossible to avoid, in so doing, the formation of a little chlorine, I add a small quantity of protochloride of iron, or even iron filings, which absorbs the free chlorine.*

When the acid contains no sulphurous acid, I convey a known quantity into a tubulated retort, adapt a tube in form of an S to the tubulure, and to the mouth a Woulf's apparatus, the jars of which contain distilled water, and are surrounded by cold water.†

The apparatus thus arranged, I introduce, by means of the tube S, a quantity of sulphuric acid of spec. grav. 1.834, twice that of the hydrochloric acid. For this purpose, I employ a funnel, drawn out, which is fixed in a firm manner above the tube, and in which rests an inverted flask containing sulphuric acid, which allows of the operation going on alone. The sulphuric acid combines with the water and liberates the gas, which dissolves in the water of the jars. It is important to employ concentrated hydrochloric acid (spec. grav. 1.178;) without this precaution, the gaseous acid would not be evolved immediately, and it would be less easy to obtain the whole. When the whole of the sulphuric acid has been added, the liquid is heated gradually to boiling; it then contains no more hydrochloric acid. Thus obtained, the hydrochloric acid is chemically pure;‡ and in this operation, the expenses are reduced to the concentration of the acid, which, brought from 1.628 to 1.834, may serve again for the same purpose, and even for the less delicate operations in the arts, and of the laboratory. It might also be used in many cases just as it is, *i. e.* at 1.628; and lastly, a manufacturer of chemicals who would purify hydrochloric acid by this means, would not have to employ heat, in order to obtain the last portions of the gaseous acid, as the weak sulphuric acid, containing the hydrochloric acid, may be employed in the preparation of this latter.—*Journ. de Pharm.*, March.

Chem. Gazette.

* When iron filings are employed, they must contain no copper, which would react on the sulphuric acid, and cause it to pass again into the state of sulphurous acid.

† I bring no water into the first jar, because at the end of the operation a small quantity of acid water passes over, and even of pure water, if the operation is carried too far.

‡ If the acid to be purified, contain arsenic, only the first portions are pure, and even then it is necessary that it should be concentrated at least to 1.178, to avoid the disengagement of any heat on the addition of sulphuric acid. This result is owing to the extreme volatility of the chloride of arsenic.

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Galvanized Iron.

About five years since a patent was taken out in this country, by M. Sorel, for the purpose of galvanizing iron, by a process of coating it with zinc, in a similar manner to tinning, but for some cause, we believe a dispute among certain capitalists, this patent has been allowed to remain in abeyance, during which period, it has been in considerable use in France, and is, at the present time, we understand, extensively employed by the French government. It is now taken up in this country by some spirited individuals, who have established large works in London for zincing iron to any extent. The process may be applied to both cast and wrought iron in any form.

"The effect of zinc in protecting iron from oxidation," says Professor Graham, "has been known to chemists for some time. When these two metals are in contact, an electrical, or galvanic, relation is established between them, by which the iron ceases to be susceptible of corrosion by dilute acids, saline solution, or atmospheric humidity. It was found in experiments lately conducted at Dublin and Liverpool, that small pieces of zinc attached to each link of a chain-cable, were adequate to defend it from corrosion in sea water. The protection was observed to be complete, even in the upper portion of the iron chains by which buoys are moored, (and which, from being alternately exposed to sea water and air, is particularly liable to oxidation,) so long as the zinc remained in contact with the iron links. The protecting influence of the zinc could not be more certainly secured than in the articles prepared by the patent process, the iron surface being uniformly coated over by that metal. In trials to which I have had an opportunity of subjecting them, the iron escaped untouched in acid liquids, so long as a particle of the zinc covering remained undissolved. The same protection is afforded to iron in the open atmosphere by zinc, with a loss of its own substance, which is inappreciably minute. The zinc covering has the advantage over tinning, that, although it may be worn off, and the iron below it partially exposed, the iron is still secured from oxidation by the galvanic action, while the smallest quantity of zinc remains upon it; whereas tin, in common tin plate, affords no protection of this kind, and not being absolutely impermeable to air and moisture, the iron under it soon begins to rust in a damp atmosphere. The simplicity and perfect efficacy of the means employed to defend iron from the wasting influence of air and humidity in this process of *zinc tinning*, certainly entitle it to be ranked as one of the most valuable economical discoveries of the age."

Civ. Eng. and Arch. Jour.

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JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

SEPTEMBER, 1843.

Franklin Institute.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on the best modes of Paving Highways.

The Committee on Science and the Arts, constituted by the Franklin Institute, of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the following portion of a joint resolution of the Select and Common Councils of the City of Philadelphia, passed January 5th, 1843, to wit: "Resolved, That the Franklin Institute, be requested to communicate to Councils, any information they may think proper, in relation to the best modes of paving highways," REPORT thereon as follows:

That they entered upon the subject referred to them, in February last, that, at various meetings since, they have discussed numerous questions connected with the subject of paving, and that they have received testimony relative thereto, from a number of persons whose opinions are entitled to respect, and who appeared, by request, before their sub-committee.

With the view of setting out the results of our labors with greater perspicuity, we shall divide the subject into eight sections, treating, in the first place, of the leading pavements in use, and, ultimately, of those which seem most suitable to Philadelphia, to wit:

SECTION I. *Preliminary Observations.*
" II. *Asphaltic Pavements.*
" III. *Wooden Pavements.*
" IV. *Stone Pavements.*
" V. *Pavements suitable to Philadelphia.*
" VI. *Plans and Specifications of the Pavements Recommended.*
" VII. *Superintendence and Mode of Executing the Work.*
" VIII. *Concluding Observations.*

consideration of street pavements, fit for the internal intercourse of cities; neither do we propose treating of the merits of the various modes of constructing roads, since many of the maxims of roadway engineering, though extremely judicious, when applied to highways *between cities*, are, to a great degree, inapplicable to streets *within them.*

Section I.

Preliminary Observations.

Since the thirteenth century, when regular pavements appear to have been commenced, within the limits of the leading cities of Europe, numerous plans have been projected, by ingenious men, for the amelioration of the public streets, and not a few patents have been procured in France and England, having, for their objects, improvements in the constructions of pavements, or the application of new materials to that use.

But as it is not our intention, either to enter into the early history of paved roads, or to attempt a record of the innumerable projects, both useful and abortive, which have been from time to time brought forward for the improvement of highways, and, particularly, of streets; we shall dispense with historical detail, and confine ourselves to a discussion of those species of pavements which have, of late years, the most engaged public attention, or have been the most in use.

These may conveniently be divided into three general classes, namely, *Asphaltic Pavements*, *Wooden Pavements*, and *Stone Pavements.*

From these, our deliberations have led us to select certain modes of paving, which would seem to be proper for Philadelphia, and which, in due course, we shall come to describe.

A good pavement ought to combine stability, and moderate smoothness of surface, with facility of removal and replacement, and be as free as possible from noise and dust.

To secure these important requisites, and, at the same time, to establish a completely stable foundation for pavements, is extremely difficult, if, indeed, it be not to a great degree, *impracticable.*

For, in consequence of the underground works of modern cities, such as sewers, gas pipes, and water conduits, to which access at all points must be allowed, for the purposes of repair, and attachment: the pavements of streets, must, if possible, combine with superficial goodness, such facilities of removal and replacement, as may enable the subterranean works to be reached at will, without serious impediment.

Unfortunately these conditions, which appear to exercise a paramount control over the streets of modern cities, absolutely preclude the employment of *concrete*, or *mortared masonry*, for the foundations of pavements; and also forbid the use of a very adhesive cement, between the paving stones themselves. Since all these methods, though beyond any question, of high importance to the

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formation of permanent pavements, *such, for instance, as the celebrated Roman ways*, appear to be inadmissible, from the fact, that they would make extremely difficult, if they did not entirely cut off, the necessary access to the underground works of the city.

It is these preliminary considerations which have prevailed with us, over a strong desire to suggest the use of *concrete foundations*, in which, upon well drained ground, we have entire confidence, and which would otherwise have been recommended by us.

A thorough system of under drainage, is of great importance to the stability and success of pavements, and the *sewage* of every great city ought, certainly, to be as carefully planned, and, eventually, almost as thoroughly carried out, as the system of the water conduits usually is.

The leading cities of Europe appear to be now sensible of the important influence exercised by a good sewage, upon the health and comfort of their inhabitants, and the stability of their pavements.

The intelligent gentlemen who testified before us, unanimously concurred in representing the superior durability of the pebble pavements, in those streets beneath which sewers run; and, in point of fact, that the surface water should be rapidly drained off in wet weather, and not be allowed to run long distances over the surface, and sink into, and saturate the undrained bed of the pavements, seems to be indispensable to their durability, and to the easy maintainance of a regular surface.

That Milan is one of the best, or, perhaps, the very best paved city in Europe, is as much owing to the fact, that every street has its sewer, with openings at short distances to receive the surface water, as to the system of paving employed, or to the mildness of the climate there.

An additional reason for the success of the street pavements in the Italian, Austrian, and other cities of Europe, may, however, be found in the fact, that, with the exception of London, Paris, and a few others, the travel upon the highways there, within the limits of the several towns, is far inferior in weight, and destructive action upon pavements, to that for which the highways of American cities must be planned, and to which they are continually exposed.

Section II.

Asphaltic Pavement.

We learn from the "*Papers on Practical Engineering,*" published for the use of the engineer officers of our army, under the direction of Col. J. G. Totten, Chief Engineer, and from other sources, that the bituminous mastic, commonly called the *Asphalte of Seyssel*, which appears to have acquired as high a reputation as any other composition of this nature, consists of a bituminous limestone, found in the Jura mountains, on the eastern frontier of France.

This stone is first roasted, then reduced to powder, and finally mixed up with about seven per cent. of mineral tar, or bitumen extracted from a mineral compound, called the *molasse*, which yields from fifteen to eighteen per cent. of mineral tar, when treated with boiling water.

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"This tar, and the prepared calcareous asphaltum, are thrown together in the proportion of 93 per cent. of the latter, to 7 per cent. of the former, and thoroughly incorporated, by stirring the mixture in iron caldrons, while hot."

The success which attended the use of the *Asphalte of Seyssel,* and its kindred bituminous mastics, in the construction of footways, and other similar surfaces, to which they have, of late years been advantageously applied; naturally produced in the minds of many, a desire to have them used in the formation of highways for carriages; and accordingly, a pavement composed of fragments of quartz, cemented together by a very adhesive bituminous mastic, was laid in 1837, at the entrance of the "Place de la Concorde," in Paris, where it became immediately subjected to a prodigious travel, and for a short time it answered well, but ultimately proved to be a decided failure, and has since (we believe) been replaced by squared granite blocks.

M. Partiot, Chief Engineer, and Director General of Roads and Bridges, in France, has stated the cause of the failure of the bituminous pavement in the "Place de la Concorde" to be;

"That the contractor erroneously considered that his bituminous mastic was capable of resisting *the direct action* of the wheels, and horses' feet."

"This mastic which attaches itself very strongly to the stones, *should be used only for cementing them together, so as to form one solid block, but it should not be visible, the stone alone being seen on the surface.*"

"The stones of this pavement were not placed near enough together, and the intervals were filled with bituminous mastic, which is not capable of resisting the friction, so that the joints opened, and the surface of the pavement became rutty and uneven, *after only six months use.*"

We may here remark, in corroboration of the above, that the experience had in the application of the Asphalte of Seyssel, as it has been compounded, and used for floors and footways in Philadelphia, (which have been closely examined by the committee,) and the ease with which it may be indented, by moderate pressure upon small surfaces—such, for instance, as the feet of chairs—sufficiently indicates that this material, either alone, or combined with stones, may not be successfully applied to carriage ways, where its surface is exposed to the action of wheels, and to the feet of horses, as in a street, even if its great expense did not present an insuperable barrier to its adoption.

M. Partiot, the engineer above quoted, has expressed an opinion highly favorable to the use of bituminous mastics, *as a cement*, for uniting stones together in paving; but we need scarcely say, that if it is to be used in that manner alone, merely to form a bond of union, however good, between the stones of a paving, which are themselves entirely relied on to carry the passing weights, and to withstand the wear and tear of the travel, *the very name of bituminous, or asphaltic pavement becomes a misnomer;* since that term would certainly imply, that the asphaltic mastic was itself the predominating material,

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successfully enter into the composition of a pavement, designed for the use of heavy carriages; and even in that mode, it would probably cement the stones together so strongly, as to render the access to the underground works of the city, difficult, troublesome, and, therefore, be *objectionable.*

The various *asphaltes,* though they have been made very much the objects of speculation abroad, by numerous joint stock companies, (some of them fraudulent) and by a great many patentees, and, consequently, have had their utility, and proper scope of application, greatly exaggerated by interested parties, are, nevertheless, very useful, though expensive, materials in construction.

Asphalte has been very successfully employed in military works, as a water-proof covering for the vaults of casemates, the floors of barracks, the roofs of military buildings, the footways of bridges, and other similar purposes, in Military Engineering.

It has also been used, to some extent, in the cavalry stables in France, but has not been applied in those of the Empire of Austria, though proposed for that purpose, and examined by the military engineers with that object, as we are informed, by an officer of that corps, temporarily resident here.

The footways of the Pont Royal, at Paris, formed of Asphalte, $\frac{52}{100}$ of an inch thick, required to be renewed within *five years,* though M. Partiot, in a careful calculation, had previously computed its period of duration at *seven years.*

Nevertheless, *asphalte* may be made exceedingly useful for footways, if, by a more sparing use of the mineral tar in its composition, it be made sufficiently stiff to resist the summer's sun, without injurious softening; it will, however, be much more expensive than the common "*herring-bone*" pavement of brick, so much employed in the American cities.

Finally, from the considerations above recited, *we conceive, that Asphalte, in any of the forms in which it has yet been used, cannot be recommended for the carriage ways of cities:* and, in support of this opinion, we may mention, in conclusion, that the *asphaltic pavements,* which, by way of trial, were laid some years since, in Oxford street, and in the Vauxhall road, in London, have entirely failed, or proved unsuccessful.

Section III.

Wooden Pavement.

This species of pavement, like that of asphalte, discussed in the preceding section, may be regarded as an innovation of the present century, since it is but recently that either have been introduced into our cities, as a part of the general system of paving.

Although a good deal of experience has now been had, in the use of *wooden paving,* both here, and elsewhere; there is yet a great diversity of opinion, as to the results, even amongst those who have for years daily witnessed the action of such pavements.

Discussions, warm, and even acrimonious, have been for some

merits of pavements of wood, of which large surfaces are now laid within the limits of that great metropolis.

Within the course of last year, forty thousand superficial yards, (or an extent nearly equal to thirty-six of our east and west squares,) were laid down by a single company—the Metropolitan—which has for some years been organized, with the view of introducing a particular form of wooden pavement into London; the same, in fact, as that laid in Walnut street, east of Third, and known as the plan of the Count De'Lisle.

We learn, on the one hand, that the authorities of Mary-le-bone Parish, in London, after long and patient trial, in Oxford, and other streets, and after much deliberation upon this subject, *have recently resolved to lay no more wooden pavements for three years:* and, on the other hand, we find it alleged, that this decision has not been well grounded upon the facts developed by the experience of London; and we further find, that some of the original opponents of wooden pavements, have since recanted their opposition.

With this maze of conflicting testimony before us, it is difficult to arrive at the true state of the case elsewhere; but it is quite certain, that wooden paving has not fulfilled the expectations of its projectors, though it was scarcely to have been anticipated, that it would have fully done so.

Wood paving, undoubtedly, possesses some peculiar advantages of a very decided character, amongst which, we may name the almost total extinction of noise—the reduction in the wear and tear of vehicles, arising from its regularity, and elasticity of surface—the ease of draught upon it—its cleanly condition—and the surprising manner in which it resists *mere wear.* On the other hand, besides its original expense, and want of durability when the wood is employed in its natural state, a very leading objection against the use of wooden pavements in cities, is to be found in their *slipperiness,* or the insecurity of the horses' foothold thereon, especially in wet weather.

So serious an objection is this, in the humid climate of London, that a leading scientific periodical, though, itself, favorable to wooden paving, describes the slipping of the horses upon such pavements there, after a shower, as being "*truly awful.*"

It seems that at such times it is difficult to stop an omnibus, for if the horses are suddenly pulled up, when in a trot, they slide forward, and often fall down, with injury to their harness and themselves.

This objection, though not so serious in our drier climate, applies, nevertheless, to a considerable extent, to the wooden pavements of Philadelphia, as many of our citizens have noticed.

Attempts to obviate this difficulty in Europe, have been productive of many patents, designing to provide a more secure foothold for the horses, by cutting the tops of the blocks, or their upper edges, so as to form a series of grooves, striating the surface of the wooden pavement in various directions transversely, or diagonally, according to a plan fixed by each patentee.

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With regard to this remedy, it must be remarked, that if to furnish a stronger foothold, and avoid accidents to horses, it becomes necessary to cut the surface of a wooden pavement into grooves, besides the expense of that operation, two of the leading advantages of such paving, namely, ease of draught, and absence of noise, will be to a considerable extent impaired.

To maintain a regular and even surface with a wooden pavement, without which it could claim but little advantage, it seems to be necessary that it should be placed upon a very stable foundation; indeed, the Civil Engineer and Architect's Journal, in an able article advocating the cause of wooden pavements, admits, *that without a concrete foundation, to use wood for paving, would be a mere quackery, and a waste of money.*

Now, a concrete foundation, of proper solidity, presenting a barrier against the necessary access to the underground works of a city, conflicts with the maxim set out in our preliminary observations, and is, therefore, inadmissible on that ground, to say nothing of its cost, if so laid. With regard to the durability of wooden pavements, experience in Philadelphia has shown that *about three years* is the limit of duration for pavements of *hemlock;* but those of *yellow pine* and *white cedar,* promise to have a somewhat longer period.

We learn that in Russia the wooden pavements require renewal at intervals of about five years; and judging from sufficient experience of the decay of the sleepers of rail roads, which, like pavements, are in contact with the ground, (though upon the side, instead of end grain,) we cannot hope that pavements of *oak, or pine wood,* would last, upon an average, *more than six or seven years, at the furthest.*

It must also be observed, that the blocks of wooden paving, being placed in conjunction with each other sidewise, become peculiarly liable to that speedy rot, which seems inseparable from the lateral contact of wood; since it may be everywhere noticed in construction, and, particularly, in damp situations, that wherever timbers are in close contact, as at joints, and intersections, *there the progress of decay is invariably more rapid,* and this well known fact, may, in part, account for the speedy decay, evinced by the wooden pavements of this place.

From this it appears to follow as a necessary consequence, that to render wooden pavements satisfactory, the timber must be, if possible, preserved from decay to such an extent, as will essentially prolong its durability.

It is important, then, in this connexion, that we should now consider some of the means by which the durability of timber may be prolonged, though we do not intend to describe, or even to mention, all the antiseptic projects devised, or tried.

William Chapman, of Newcastle, England, a civil engineer of distinction and experience, published at London, in 1817, a treatise "*On the Preservation of Timber,*" in which he recorded numerous experiments made by himself, upon different woods impregnated with various substances; and he also embodied most of the practical knowledge then extant upon that subject.

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He states that as long since as 1792, it was proposed to soak timber in copperas water, with a view to its preservation; it having often been observed, that many of the timbers used about copperas works, acquired surprising durability, when frequently exposed to the action of a solution of that substance.

In this work, Mr. Chapman announced, *that all the metallic salts were, more or less, antiseptic in their nature, and that when timber was impregnated with them, they coagulated the albumen of the wood, and had considerable effect in preserving the whole from decay.*

This principle so explicitly set forth—that of coagulating the albumen of the wood, by a metallic salt, and thus forming an insoluble and indestructible compound—is precisely the one which sundry modern projectors have seized upon with avidity, and sought to appropriate to their own use by letters patent; but few of which, however, could successfully stand the test of a legal discussion, if Chapman's treatise were given in evidence.

It further appears from Mr. Chapman's work, that boiling timber for three or four hours in a saturated solution of green vitriol, (sulphate of iron, or copperas,) has long been in use in Sweden; that it is found very advantageous there in preserving wood from decay; and that most of the timber used in that country for carriages, is thus prepared. We doubt, however, the utility of *boiling*.

Mr. Chapman tried impregnating timber with solutions of lime, and with coal tar oil, but neither of these proved to be satisfactory defences against decay; and he observes, relative to impregnation with salts of iron, "that the acetous fermentation should take place in the sap of timber, before it be macerated in a solution of copperas;" and observing this precaution, he projected the preparation of timber for the Royal Navy on a grand scale, by immersion in saturated solutions of sulphate of iron.

He also tried numerous experiments, by immersing pieces of wood in solutions of various metallic salts, such as nitrate of silver, corrosive sublimate, sulphate of copper, sulphate of iron, *and of the two latter salts combined.*

Mr. Chapman drew from these experiments, the inference, that in coagulating the albumen of wood, "the sulphates of copper and iron were both effective, and nitrate of silver, and corrosive sublimate, decidedly so;" and hence, he concludes, that thorough impregnation with any of these metallic salts, would prove decidedly antiseptic in its effects upon timber; though from motives of economy, he gave a preference to the use of a saturated solution of copperas.

The treatment above described, was designed by Mr. Chapman, to be preventive of decay; but he also used, with decided effect, as a remedy for dry rot already begun, a wash composed of *hot solutions* of sulphate of copper, of sulphate of iron, and of both these salts combined.

Sir Humphrey Davy, many years ago, proposed, as the result of some examination, a wash of corrosive sublimate, as a remedy for dry rot.

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gold, in 1824, in his able and widely circulated treatise upon Carpentry, by which work, a notice of these antiseptics was extensively spread amongst artificers.

Thomas Wade, in a work published in 1815, mentions "that timber may be impregnated to advantage, with any of the following sulphates, viz., of *copper, zinc, or iron.*"

Robert McWilliam, Architect and Surveyor, in a treatise on the Dry Rot, published in 1818, says, "that of metallic salts I have frequently used with success, (for the prevention of dry rot) the sulphates of *copper, iron,* and *zinc;*" and he finally concludes, from all his experiments and observations, "*that any mode of impregnation by which timber can be made close, solid, and hard, in its whole bulk, or in its parts, so as to make it repel air and moisture, will secure its durability.*"

John Knowles, Secretary to the Surveyors of the English Navy, in a memoir published many years since, enumerated various proposed preservatives for timber, amongst which were the sulphates of copper, iron, and zinc, corrosive sublimate, eleven salts of earths and alkalies, and two acids.

McWilliam, in the treatise upon Dry Rot, above mentioned, says distinctly, "that *various preparations* of different metals have likewise been used with success, (to prevent decay in timber) particularly those of *iron, copper, and zinc.*

Upon the ample basis afforded them by the investigations and remarks of the writers above quoted, numerous individuals have grounded patents, and sought the aid of their respective governments, to enable them to monopolize the use of several preservatives for timber, which had long previously been used, or suggested, by others.

Amongst these patentees, the most prominent, are Bill, Kyan, and Burnet, in England; and Earle, in our own country.

Bill's patent is, (we believe,) for the impregnation of wood, with a preparation of coal tar.

Burnet's patent is for impregnating timber with the chloride of zinc, aided now by exhaustion, and subsequent pressure.

Although timbers prepared by both of these patent processes, have been subjected to some strong tests with favorable results; and though Burnet's process has recently found some strenuous advocates, and is now being introduced upon a large scale into the English dock-yards, neither of them have, as yet, been very extensively employed.

The antiseptic processes generally known as those of Kyan, in England, and of Earle, in this country, appear to have acquired the greatest notoriety, and have probably been more extensively used, than any of the others.

Kyan's process, which, under the name of *kyanizing*, has even added a word to our language, consists of steeping timber in a solution of the corrosive sublimate of mercury, formed in the proportion of 1 lb. of cor. sub. to 5 galls. of water, and continuing the immersion for a longer, or shorter period, according to the dimensions of the stick of timber immersed.

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Mr. Kyan appears to have taken out *two patents*, the first under date of March 31st, 1832, (see London Rep. Pat. Invent. vol. xiv, p. 276,) was mainly, *for the preservation of wood*, by means of corrosive sublimate: the second under date of September 22nd, 1832, (see Newton's Journal of Arts, &c., vol. iii, conjd. series, p. 86; and Rep. Pat. Invent. vol. xvi, p. 9,) was confined in its application to such vegetable substances, or fabrics, as *paper*, *canvas*, *cloth*, *cordage*, *&c.*

We have before stated, that the application of corrosive sublimate of mercury, to vegetable substances, as an antiseptic, had been, many years before, prescribed by Chapman, and Davy, and had even been directly applied, by the former, with success, to the preservation of wood; still, as the efforts of these distinguished men had failed to attract the attention, or command the confidence of the public, to an extent sufficient to introduce this antiseptic into use amongst practicians; Mr. Kyan deserves credit just so far as he was the means of reproducing the invention, demonstrating its utility anew, and finally of introducing it into constructions at large, and rendering it generally available for practical purposes.

Nevertheless, that Mr. Kyan was enabled to obtain a patent for this process at all, is probably owing entirely to the English practice of granting letters patent for anything where the fees are paid, and leaving to the courts of law alone, the determination of the whole question of validity.

It is not probable that Kyan's process, as it is commonly called, can be sustained under the American general law of patents, since solutions of corrosive sublimate had been successfully used for the preservation of wood by Chapman, many years before; and in the language of our law, "*had been described in a printed publication, in a foreign country;*" that, therefore, the composition of matter employed by Mr. Kyan, had been, in the words of the same section, "*known, or used by others, before his discovery, or invention thereof;*" and, consequently, under the act of Congress, of July 4th, 1836, to which we now refer, a patent therefor, would seem to be untenable.*

We may here observe, that McWilliam has made the valuable observation, that the trees which are the most readily and advantageously impregnated with salts of iron, are those abounding with "the astringent principle (tannin and gallic acid):" whilst the "*coniferae,*" or trees of the pine family, being of a resinous, and not of an astringent nature, are but little affected by antiseptic preparations of iron.

This shows the propriety of confining the application of salts of iron mainly to such timber as *oak*, *elm*, *chesnut*, *ash*, *&c.*; and it may probably account for the very slight effect produced by the iron antiseptics upon resinous timber, as may be illustrated by the failure of Earle's process, as applied to hemlock pavement in this city.

In Earle's process for preserving timber from decay, for which letters patent of the United States, issued upon the 20th of September, 1838, the claim of the inventor is substantially as follows:

"For the boiling of timber in a solution of sulphates of iron and copper.

* Nevertheless, Mr. Kyan, by special act of Congress, obtained a patent from the United States, under date of June 23rd, 1838, (see vol. xxiii. of this journal, p. 396, with the Editor's remarks.)

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solution from two to five, or six hours, or more."

The only novelty of this process of Earle's,* consists in *the boiling of the timber in* the particular solution named, that solution itself having been used in a cold state, for the same purpose, by Chapman, prior to 1817; and having also been long since applied *hot*, as a wash to preserve timber from decay, or to cure the dry rot.

The utility of boiling timber is very doubtful, and by McWilliam, in his treatise upon Dry Rot, it is pronounced *"to be positively injurious."*

It appears to us that the antiseptic properties of metallic salts, are nowise impaired by employing them in cold solutions, and that their activity cannot be much—if it be at all—augmented by the operation of *boiling*, which increases the trouble and expense, without, as far as we can perceive, attaining any valuable end, not equally attainable by immersion in saturated solutions at ordinary temperatures, particularly if exhaustion and pressure be used.

In addition to the above modes of augmenting the durability of timber, impregnation *with oil*, under great pressure, has been proposed by M. Breant, and some successful experiments with wood thus prepared, have been tried in the flooring of a bridge in France.

A powerful hydrostatic pressure, following a previous exhaustion, has been found useful in promoting a thorough impregnation of timber with metallic salts in solution; and impregnation with *kreosote* has also been proposed by M. Moll, a German mechanic.

Recently a cheaper metallic salt, and a different and superior mode of thoroughly impregnating the timber, has been proposed for use by M. Boucherie, and illustrated by many experiments of a conclusive nature.

A very interesting account of this process, translated from the French, by Professor John F. Frazer, may be found in the Journal of the Franklin Institute, for 1841.

M. Boucherie's method is to employ the impure pyrolignite of iron, as the antiseptic salt of impregnation, and to cause it to insinuate itself into all the pores of the wood, by means of the singular power of aspiration, developed by the sap of newly felled trees.

M. Boucherie's plan, in brief, is to fell the trees, and lop off all the branches except the top; then to connect the lower end of the trunk, by means of a water-tight bag, or any other suitable means, with a reservoir containing a saturated solution of the impure pyrolignite of iron; then the sap being gradually exhaled from the leaves remaining upon the upper branches, the ferruginous liquid is drawn up into the body of the tree, until, in a few days, it reaches the uttermost branches, and fills all the capillary tubes of the timber, coagulating, and solidifying in its progress, all the albumen of the wood, and greatly augmenting its durability, by rendering it, in the words of McWilliam, *"so close, solid, and hard, as to repel air and moisture."*

Such is the force with which the sap is propelled forward through the pores of the body of a tree, in consequence of the exhalation from

***Boiling* wood in lime water, with the view of protecting it from decay, was also patented here, by Ringgold and Earle, August 6th, 1838.

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the top, when newly felled, that Dr. Hailes is his vegetable statistics, published about a century ago, mentions the case of a freshly cut vine branch, which being plunged at its lower end into mercury, drew that metal up into its tubes, to the height of *thirty-eight* inches; thus actually evincing a power superior to that with which the atmosphere acts against a vacuum!

From the satisfactory character of the numerous experiments adduced by M. Boucherie, there is strong reason to believe, that this process will be very efficacious, and as it is not expensive, it ought, certainly, to receive as full, fair, and speedy a trial in this country, as it has already had in France.

In point of fact from the results of experiments which have been made, we are led to infer, that a thorough impregnation with the salts of iron, may answer the end of considerably prolonging the durability of timber, and probably render unnecessary, the application of the more expensive salts of copper, or mercury, which seem to be more active antiseptics.

In addition to the above, we have gathered from the various English works on patents, and from the Civil Engineer and Architect's Journal, the following information, which may prove interesting in this connexion.

Murdock's Patent, May 2nd, 1791; proposed to preserve timber from decay, by a paint of sulphur, arsenic, and zinc.

Newmarch's Patent, February 25th, 1826; proposed to preserve timber from decay, by boiling it for three or four hours in a solution formed of the following materials, mixed in the proportions stated, viz., 3 oz. of sulphate, or acetate of copper, 3 oz. of white arsenic, and 1 gall. of linseed oil.

A mode of seasoning timber by placing it in an iron tank, resembling a steam boiler, and then exhausting the air from within, was patented by Langton, in 1825.

Mr. Carey, of the Royal Navy, in 1785, noticing the good effects proceeding from the plan then, as now, employed in America, of salting vessels whilst on the stocks; and, further, observing that whale ships were seldom attacked by dry rot, he conceived the idea of preserving vessels from decay, by filling all the spaces between the timbers, whilst under construction, with a mixture of oil and salt, thickened up to a proper consistency, by the addition of powdered charcoal, itself a powerful antiseptic.

With this compound Mr. Carey filled all the openings between the timbers of two vessels that he built in America in 1785, and in evidence of its efficacy, he states that in the year 1816, *or thirty years after*, he met with one of these, a brig of 200 tons burden, in the harbor of New York, which was still sound in nearly all its timbers, as he ascertained by boring many of them.

Sir William Burnet, in 1836, suggested, and was instrumental in testing on a large scale, a more effectual mode of causing antiseptic solutions to impregnate timber, than mere immersion was found to be;—this was by piling the wood within a suitable iron tank, then exhausting the tank to a partial vacuum, represented by a pressure of

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about 5 inches of mercury, then admitting the antiseptic solution; and, finally, subjecting the fluid to a pressure of about 100 lbs. to the inch above the atmosphere.

This method, with the chloride of zinc, employed as the antiseptic, has found some vigorous advocates, and is now beginning to be extensively applied abroad.

A leading objection urged against Kyan's process, is that the deutochloride of mercury employed, *does not* coagulate the albumen of the wood, or vegetable tissue, into an insoluble compound, since kyanized sails have had the corrosive sublimate so thoroughly washed out of them by the exposure of a single voyage, that an application of the usual chemical reagents failed to detect a trace of mercury.

Some wooden piles, also, which had been kyanized, and used in a sea work, were cut to pieces in a short time, by the "*teredo navalis*," or ship worm; thus rendering it probable, that in those cases, also, the corrosive sublimate had been washed out.

On the other hand it is certain that on some of the railways, kyanized sleepers have far outlasted similar sticks of unprepared timber, and are still sound.

Sir William Burnet's process of impregnating wood, &c., with a solution of the chloride of zinc, aided by exhaustion and pressure, is said to be free from the objection urged against that of Kyan; it seems to be superseding *kyanizing*, in the favor of the English Commissioners of the Admiralty, and nearly all the naval timber, sails, cordage, &c., to which antiseptics are there applied at present, are treated by Burnet's zinc antiseptic process, under the name of *burnetizing*.

One of the most recent antiseptic projects, is that of a Mr. Payne, who, calling both exhaustion and pressure to his aid, first impregnates timber with a solution of sulphate of iron, and afterwards with muriate of lime, which is said to attain the desideratum of forming an insoluble compound within the interior of the timber, and by its means, preserving the wood from decay.

We have entered thus at length into the subject of preserving timber from decay, because, without some efficacious means of augmenting its durability, the employment of wood as a material for paving, will, of necessity, be precluded by its expense, even if other objections should be overcome; and, because, with the use of proper antiseptics, we should still hope, that in particular situations, where absence of noise is paramount to all other considerations, wooden pavements may yet be used with advantage.

Locust and Red Cedar, which are justly esteemed as the two most durable woods accessible to us, have both been suggested as materials for paving streets; but it appears to us, that pavements of either of these, would probably be much too costly for ordinary use, even if the latter were sufficiently hard to withstand the action of the travel with success, or if, in both, the slipperiness of their surfaces could be obviated.

As an evidence of the costly character of the wooden pavements which have yet been laid in Philadelphia, we may refer to the following:

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yard; *and was decayed to such an extent, as to require renewal within three years.* This wooden pavement has recently been replaced by squared stone blocks, upon a gravel foundation, and laid upon the rectangular system.

2. The squared block wooden pavement, in Third street, north of Spruce, cost about $2.25 per square yard; and after *three and a half years use*, the hemlock portion of it is very much decayed, and needs renewal, while the heart yellow pine portion is still in apparent good order, though presenting strong symptoms of decay. This pavement was laid in September, 1839, and the hemlock portion, now patched in many places with pebble paving, will probably require removal in the course of the present year, 1843.

3. The wooden pavement of white cedar, formed of oblique prisms (doweled together) upon the Count De Lisle's plan, which was laid in Walnut street, east of Third, in 1840, cost $1.75, per square yard, and is still in good order.

4. The cubical hemlock pavement, in front of the State House, in Chesnut, between Fifth and Sixth streets, which was laid in July. 1839, cost about $2 per square yard; and after but four years use, had so extensively decayed, that it has this year (1843) been replaced by a cubical pavement of stone, laid upon the diagonal plan.

5. The squared hemlock block pavement, laid in Spruce street, between Tenth and Eleventh, cost about $2 per square yard of surface; it was laid in November, 1839, and though exposed to very little travel, it now exhibits unequivocal symptoms of speedy destruction.

In three of the above instances, viz., in Third street, north of Spruce, in Spruce, from Tenth to Eleventh, and in Walnut, east of Third, the expenses of the wooden pavements were partly borne by voluntary private subscription, as an inducement to the authorities of the city, to use wood in those streets.

The hemlock, which has been chiefly used in Philadelphia, for the wooden paving, is certainly the most unsuitable timber that could have been employed for such a purpose; nevertheless, its very rapid decay shows, but too clearly, the great liability of wood, in general, to rot under such circumstances; a consequence of which is, *that without the economical and successful application of antiseptics, to prolong its durability, wood must be given up as an economical pavement, unless future experience should indicate some wood, combining cheapness, with durability.*

The necessity of applying preservatives to the timber used in wooden paving, is strongly inculcated by the expensive experience of Philadelphia; and it is, consequently, a matter of regret, that such indifferent success has attended the application of Earle's process, to the first fifty feet of wooden pavement now laid in Sixth street, south of Chesnut; *many of the blocks of which are much decayed at this time,* though, by way of apology, it is asserted, that they were originally affected by rot, prior to being boiled in the solution of the sulphates of copper and iron, as prescribed in the patent of Dr. Earle.

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It has been alleged with some truth, that wooden paving resists the wear and tear of the travel, in an equal degree with some stones that have been employed, but this assertion requires limitation; for although it is true to an unexpected extent, whilst the timber remains *perfectly sound,* yet the moment the coherence of its parts becomes impaired by the progress of decay, it yields to the travel with extreme rapidity, and quickly wears in holes: this may be witnessed in most of the older wooden pavements, where the middle of the carriage-way, being the most exposed to travel, has worn into deep unequal hollows, whilst next to the gutters, where they are less exposed to the action of the wheels of passing vehicles, the blocks retain their figure well, and though not less extensively decayed than the rest, they do not show it so soon.

Now, inasmuch as wooden pavements undoubtedly possess advantages which would render them useful at some points, and as experience abroad has not yet *definitively* decided upon their merits, we are not disposed, at this time, to condemn them entirely; but we would recommend to the Councils of Philadelphia, *to abide the result of the extensive practice of London, and other cities, where wooden pavements are now undergoing ample experiments,* and in the meanwhile—if they see fit—to lay, for trial, say *three* experimental intersections, in some well traveled street, with wooden pavements, as follows:

1. Of sound *Locust* timber.
2. Of sound and seasoned *White Oak,* prepared by immersion for one month, in a saturated solution of sulphate of iron.
3. Of *White Oak* prepared by Boucherie's process.

As no patent right would interfere, these experimental intersections, covering but little upwards of two hundred superficial yards in all, would cost but a small sum; and being laid in an economical manner, upon a pebble pavement foundation, (as specified in the Sixth Section following, for pavements of squared stone,) their construction would enable an estimate to be formed, of the probable expense of good wooden pavements upon larger areas; whilst, in a few years, they would clearly show what may be expected from pavements of wood, either of a quality well known for durability, or of other timber impregnated with antiseptics.

Finally, in consequence of the slippery nature of their surfaces, of their deficient durability when of ordinary timber, of their expense, immediate, or ultimate, and in view of the results of experience, as far as they have become known to us, we are reluctantly impelled to the conclusion, that though their use may be proper in some detached situations, *wooden pavements ought not, at this time, to be recommended as a part of a general system of paving, for the city of Philadelphia.*

In support of the above conclusion, it is proper to state, that since the preceding portion of this report was written, we have learned that the authorities of the city of New York, have determined to take up their decayed wooden pavements, and relay them with *stone;* whilst

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the necessity of this renewal, declare that the wooden pavements there, have proved a signal failure.

We regret to learn that the experience of Boston, with regard to the deficient durability of pavements of wood, has been almost as decisive and unfavorable, as that of Philadelphia and New York; and it is also corroborative of the propriety of the opinion we have ventured to express *against the employment of wooden pavements here at the present time.*

Section IV.

Stone Pavements.

We now come to the consideration of stone pavements: traces of these, of the highest antiquity, are to be found in Egypt, but they are supposed to have been first employed as a regular system, by the Carthagenians; and after the subjugation of Carthage by the Romans, they were brought to the highest degree of perfection, by that conquering people, and pushed by them for military purposes, and with a characteristic energy, even into the remotest provinces of their mighty empire.

The Roman highways of dressed stone, usually polyangular, fitted with surprising neatness, and placed upon a solid foundation *of concrete, or masonry,* have formed the prototypes of modern constructions of this nature, and are scarcely to be surpassed in durability: some of them, in fact, being now in use, after having successfully withstood the travel and wear of fifteen centuries; though it must be remarked, that where such is the case, the travel is not to be compared in weight, or destructive action, with that which continually traverses the streets of modern cities.

The stone pavements in common use, may, with propriety, be considered under three separate heads, namely:

1. *Of pavements of dressed stone.*
2. *Of pebble pavements.*
3. *Of stone tramways combined with pebble pavements.*

All of these systems have some common points which require attention, and amongst these, is *the foundation,* which Mr. Richard Lovell Edgeworth, in his well known treatise upon Roads and Carriages, justly remarks, "is in all pavements the first thing to be attended to."

The common practice here is to make the foundation consist of about one foot in depth of gravel, thrown loosely into an excavation, and not otherwise consolidated, than by the travel of the carts, in which it is brought; this foundation, scarcely possessing sufficient strength for the most obscure and least traveled streets, is decidedly insufficient, when applied to the great thoroughfares.

Sir Henry Parnell, in his able treatise upon Roads, which has become a text book in these affairs, states that "the chief defects of all pavements arise from neglecting to give the stones a proper shape, and to construct a substantial foundation to support them."

The first question to be determined then, is, what foundation should be employed in pavements here?

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for reasons that seem to be sufficient.

What then shall we employ for a foundation, which shall at once present sufficient solidity, and yet will not cut off the access to the underground works of the city?

It has been satisfactorily shown in the case of Fleet street, in London, referred to by Sir Henry Parnell, that a mere mass, or bed of broken stone, even if 12 or 18 inches in depth, when loosely thrown in, and leveled off, is totally insufficient to form a good foundation for a pavement; and that the only mode in which broken stone foundations can be made to succeed, is by forming the metal into a regular macadamized road, and consolidating it under the travel in *thin layers*, as is usual in such cases.

Sir Thomas Telford, the distinguished engineer, in his report upon the street pavements of the parish of St. George, says that, "as relates to the metropolis generally, I am persuaded that a bed of cleansed river ballast, *(gravel stones)* about six inches in thickness upon an average, will be found to answer the purpose (of a foundation)."

But in 1833, he remarked upon this same point, "that on reconsidering this subject, I am of opinion that this quantity of ballast will not make a sufficiently strong bottoming, and that nothing short of twelve inches of broken stones, put on in layers of four inches each, and then completely consolidated by carriages passing over them, will answer the purpose."

Now, the formation of a complete macadamized road, as a foundation for a street pavement, as recommended by Telford, (though, undoubtedly, sufficient for the purpose,) would be both inconvenient and expensive, while from its solidity, it would present a serious obstacle to any excavations which might become necessary in the street.

But there is another mode of forming a foundation for a pavement, which seems to satisfy the conditions we have set out; and with regard to a similar plan, recommended by Sir Henry Parnell, that author makes the following remarks:

"In those streets where there is a constant passing of carriages, both night and day, such as the Strand, Fleet street, Holborn, Cheapside, Piccadilly, and Oxford street, (in London) the foundation for the pavement, should be *a sub-pavement*, made of old paving stones, or any kind of coarse stone; and this should be laid upon a bed of broken stones. This mode of paving is in use in Paris. *In the autumn of 1825, for instance, the old pavement of the Rue Dauphine was taken up and relaid on a bed of gravel to form the foundation for the new pavement. This practice has proved completely successful.*"

This mode of laying new pavements upon foundations formed by a sub-pavement, made of the stones of the old one, is still practiced with success, in the streets of Paris.

In view of all the experience upon this point, the best mode of forming the foundation of a dressed stone pavement—suitable for the principal thoroughfares of a great city—which, after much considera-

tion, has suggested itself to us, as giving sufficient stability, without involving too great an expense, or being attended with any serious inconvenience, *is to use a common pebble pavement for that purpose:* while, in other streets, where the travel is less, and where the pebbles themselves are retained as the paving, *the foundation of gravel may still be employed, if it be carefully consolidated in layers by rolling.*

The subject of *drainage* is intimately connected with that of foundations, and will now require our consideration.

A good drainage for the foundations of the pavements of a city, presents difficulties unknown in roadway engineering: for upon well constructed roads, mitre drains of rubble stone beneath the road surface, are made at proper intervals, to open into the side ditches, whence the water is readily drained away; and, by this means, the bed of the road can be maintained in a comparatively dry, and firm state: whilst the foundations of a street pavement, not readily admitting of this effectual lateral drainage, are much more difficult to be kept in good condition.

In many of the streets of cities, *sewers* have been omitted, in consequence of their expense, and hence much of the drainage *is merely superficial.*

It results from this, that the water which is shed from the houses, and from the sidewalks, being thrown into the depressed carriage ways of the streets, and combined with the downfall upon their surfaces, has often to run considerable distances along them, before it finds entrance to a sewer; this gives time for a great deal of the drainage water in its lengthened course, to soak down through the joints of the paving—thus saturating the foundations of the pavements, and, as a necessary consequence, rendering them weak, and liable to be broken up.

This is a great evil, and merits the closest attention of the authorities of a city, since a thorough system of underdrainage—whilst of high importance in a sanatory point of view—seems to be indispensable to the complete success, and stability of pavements.

Such, in every aspect, is the importance of a good sub-drainage, that we cannot refrain from recommending to the authorities of Philadelphia, *the immediate planning, and the gradual introduction of a complete system of sewage,* for it will not be until an underground drain exists in every leading street which has a retentive sub-soil, that the system of pavements can be rendered complete.

The mere underdrains of streets, or subordinate sewers, out of the natural lines of drainage, need not exceed two or three feet in diameter, the top being but three feet under the surface, having half brick openings occasionally, and being covered over with rubble stone, or brick rubbish, so as to admit of a free drainage, both direct and lateral.

Such underdrains may be easily located so as not to interfere with the gas, or water conduits, their expense would not be great, and if a comprehensive plan of sewage were but once adopted, and gradually put in execution, as the several streets of the city require repaving—

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with the view of finally forming an underground drain, or sewer, in every leading street, which is not on porous ground—the annual outlay would be scarcely felt, whilst the improvement of our highways would soon be apparent; superior cleanliness would be insured, and the nuisances of transverse gutters, unstable pavements, and cellars wet by overflow, would quickly disappear.

Where sewers already exist under streets, a good underdrainage may be easily effected, by forming beneath the foundation of the pavement a longitudinal trench, some two or three feet square in section, directly above the sewer, filling the trench with rubble stone, (thus forming a blind drain) and causing it to communicate with proper apertures in the top of the sewer, by dry stone wells, at two or more points, in every square of its length.

Having thus considered the important collateral points of *foundation* and *drainage*, let us now proceed to a separate discussion of the several kinds of stone pavement.

1. *Of pavements of dressed stone.*—These pavements have for a long series of years, been employed for the principal thoroughfares in the leading cities of Europe; and in combination with pebble pavements, for the more subordinate streets, they have for centuries, formed the main part of the surfaces of city highways; although often rudely dressed, and badly laid, they have uniformly held the highest place in public estimation; and though of late years many projects have come up for superseding them by wood, or asphalte, yet since most of these attempts have proved abortive, it is probable that hereafter, as heretofore, uniform surfaces of dressed stone will be the most generally approved and used, in those great thoroughfares where smooth and durable pavements are an important desideratum.

When Mr. Telford was consulted in relation to the pavements of the parish of St. George, in London, he examined this subject with great care, and, with a commendable degree of caution, prior to forming his own opinion upon the matter in hand, he submitted sundry questions relating thereto, for the deliberation of the Civil Engineer's Institution, at repeated sittings, and the conclusions arrived at, by that very intelligent body, are thus stated:

"The result of these able, and very candid discussions, was *an unanimous resolution*, that whin, or granite pavement, of proper form and depth, laid on a sound bottom, *is preferable to any other mode for carriage ways* for the metropolis, and other large cities, in order to form a body of strength, adequate to bear the pressure and shocks of innumerable carriages, many of them conveying several tons."

Dressed stone pavements are, undoubtedly, very expensive in the first instance; and hence they ought only to be used in situations where diminished traction is desirable, or where the travel is so great as to render repairs of other pavements frequently necessary; in such cases—*as in the leading thoroughfares of a great city*—the original outlay becomes of less importance, when compared with the extreme durability, and other advantages of a suitable pavement of dressed stone.

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repairs." And the same author in 1833, mentions in relation to part of a great road leading into the city of London, which was paved with granite, under the direction of James Walker, C. E., President of the Institution of Civil Engineers, "that this paving has now been in use thirteen years, with almost the heaviest traffic out of London upon it, and, except the first year, when the contractor had to keep it up under his agreement, it has cost very little for repairs. It is now in excellent order, and the stones do not appear worn in the smallest degree."

The great durability, and the ease of traction, furnished by a dressed stone pavement, of suitably dimensioned stone, when it is properly laid, and properly founded, cannot, in point of fact, be disputed, and will justify its use, even as a matter of strict economy, in all streets that have to endure a crowded and heavy travel.

In the ordinary mode of paving with stone blocks, they are placed in courses perpendicular to the line of direction of the street, as has been done in this city, at the intersection of Sixth and Chesnut, and more recently in Chesnut, between Fourth and Fifth streets; but since upon this plan a number of joints lie parallel to the axis of the carriage-way, it has been found in practice, that the wheels of passing carriages, running in both directions along these joints, soon wear down, or round off, the arrises of the dressed stone blocks, so as gradually to form ruts, or holes between them, which in time render such pavements rough and uneven, and finally cause them to break up.

M. Le Large, a French writer in 1717, recognized this defect, and in a memoir upon the different modes of paving roads with squared stone, which may be found in the third volume of the "*Machines et Inventions approuvèes par L'Academie Royale des Sciences,*" he suggested *a diagonal disposition* of the courses of stone, as a remedy therefor; and furnished two plans, or sketches, showing how the stones of a pavement might be so arranged in courses forming respectively, angles of 45°, and of 26½°, with the axis of the street.

The views of M. Le Large upon this point, were adopted and enforced by Mr. Edgeworth, in 1813, in his able essay on *Roads, &c.*, which was published at that time; but, notwithstanding the authority of this writer, and the approbation of the French Academy, *the diagonal system* of paving has not been as generally adopted as it deserves to be, though, in all probability, it will ultimately supersede the *rectangular mode.*

In the sixth volume of the Technical Repository, H. W. Revely, Civil Engineer, mentions that dressed stone pavements upon the diagonal system of large stone, *furrowed* transversely, were successfully employed long prior to 1824, "in the streets of Florence, Pisa, Leghorn, and other cities of Tuscany;" and he recommended similar pavements, laid in courses at an angle of 45° with the axis of the street, and forming salient angles in plan, at the middle of the carriage-way, as being suitable, in a high degree, for the pavements of the city of London.

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We learn from Capt. Charles Mœring, an intelligent engineer officer in the Austrian service, now on a visit here, that in the great city of Vienna, the leading thoroughfares are now uniformly paved *in the diagonal manner*, which pavements succeed admirably, and which after sufficient experience under the heavy travel of that important place, have proved themselves to be so decidedly superior to the ancient pavements upon the rectangular system, that these latter are now relaid in the diagonal form, as fast as renewals become necessary.

If we leave the results of practice for a moment, and turn to abstract considerations, we shall find that they would lead us to form a favorable opinion of the diagonal mode of paving, for it is evident, that in a good dressed stone pavement with close joints, the most favorable direction in which a carriage wheel can act upon a joint, is perpendicular thereto, while the worst, is when the wheel runs along the length of the joint; hence in a pavement where part of the joints are parallel, and part of them perpendicular to the line of travel, unequal wear must inevitably result, and a roughness of surface ensue.

At the intersections of streets, where the travel upon both carriage ways, traverses the parallel joints, the wheels running in one street, will wear one set of joints, whilst in the line of the other carriage way, the rest of the joints will be injured, and, consequently, a pavement so situated, must wear rounding, and become irregular, in the course of time.

From the nature of the case, we should, therefore, conclude, that those pavements would wear the smoothest, and last the longest, which should be laid in such manner, *that carriages passing in both directions upon their surfaces, would cross all the joints of the paving at equal angles.*

This condition will be answered upon *the diagonal system*, even at the intersections of perpendicular streets, by causing the courses of paving to form angles of 45° with the axis of the carriage way.

Another strong argument in favor of a diagonal disposition of paving stone, may be found in the recent practice of distinguished engineers, upon many of the English railways.

The heavy stone blocks, square in plan, which carry the chairs of the edge rails, were formerly disposed with their sides parallel, and perpendicular to the track, occupying the same position as in a rectangular system of pavement; but now upon the London and Birmingham, and other great railways, the squared stone blocks are all placed *so that the line of the rails traverses a diagonal*, or are, in fact, disposed in relation to the travel, precisely as they would be in the diagonal system of paving: this change in the position of railway foundations, has resulted from a just conviction upon the part of the engineers, that a stone block disposed diagonally to the travel over it, *presents superior stability, both longitudinally, and laterally, since the lines of resistance in such case, become longer in both of these directions*, and this argument we need scarcely say applies with equal force to a stone block in a paved street.

A strong argument in favor of hexagonal blocks for paving streets, may be drawn from the foregoing considerations; since, if a hexagon

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be placed horizontally in a pavement with two of its sides perpendicular to the axis of the street, the lines of travel will intersect the other four sides at angles of 30° in both directions; so that, in fact, they will cross two of the sides of the hexagon, in the most favorable direction possible, whilst all the other sides by their diagonal disposition, become more exempt from the injurious action of wheels along the joints, than would be the case with blocks of any other geometrical figure, *if set in regular transverse courses*, and would only be surpassed in this respect, by masses rectangular in plan, *and set diagonally at angles of forty-five degrees with the line of the street.*

We conclude then, *that a diagonal disposition is the best for dressed paving stone*, and having discussed the method of arrangement, we are now to consider the proper size for the stone blocks of a dressed pavement, and upon this point we find that considerable variation exists, both in successful practice, and in competent opinions.

Thus, in Naples, where stone pavements are laid upon the diagonal system, the blocks are closely jointed, are two feet square horizontally, and present a superficial area of four square feet each: in Pisa, Florence, and Leghorn, the stone blocks are also large, but in all these cases they become, by use, so dangerously smooth, as to require numerous furrows to be cut transversely to the line of travel, in order to secure a proper foothold for the passing horses; and in our own country, in the city of Boston, where a portion of Tremont street, in front of the Tremont house, is paved with granite blocks of eighteen inches square, showing two and a quarter superficial feet each, transverse furrows have also been found necessary.

These transverse furrows are laborious in execution, and also objectionable, on account of their roughness, and the noise they produce under vehicles—*fortunately they are not indispensable*—since in most of the cities of Europe, the same end has been answered by using smaller stone, and it is for this reason that in those cities, generally, the stone blocks are dressed into cubes of about two-thirds of a foot side, and showing, when set, only about one-half of a superficial foot, exposed to the travel.

Bryan Donkin, a Civil Engineer, in some interesting papers upon paving, written many years ago, proposed that dressed stone for the London pavements should be 5 inches broad, 7 to 8 inches long, and 10 to 13 inches in depth, vertically.

Sir Thomas Telford proposed for the pavements of the parish of St. George, in London, that the dimensions of the dressed paving stone should be as follows:

For streets of the—

1st. class,	10 ins. deep;	11 ins.	to	13 ins. long;	and	6 ins.	to	7½ ins. broad.
2nd.	" 9	" 9	"	12	"	5	"	7 "
3rd.	" 7 or 8	" 7	"	11	"	4½	"	6 "

Sir Henry Parnell, like Telford, divided streets into three classes, proportionate to the travel over them; and he recommended the dimensions of the dressed stone to be as follows:

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For streets of the—

1st. class,	10 ins.	deep;	10 ins.	to 15	long;	and 6 ins.	to 8 ins.	broad.
2nd.	" 8	"	8	" 12	"	" 5	" 7	"
3rd.	" 6	"	6	" 10	"	" 4	" 6	"

The French engineers have been in the habit of forming their dressed paving—*like dice*—into rigid cubes of about 8 inches side; their example has been pretty generally followed upon the continent of Europe, and we may mention, that cubes of about this size, are employed in those streets of Vienna, which have been so successfully paved in the diagonal manner.

Although the best authorities differ in some degree, as to the most suitable dimensions of paving stone in a horizontal direction, *they all agree that a rigid uniformity of depth is indispensable;* and we may here remark, that in consequence of this maxim amongst others, having been overlooked, or neglected, in laying recently the dressed stone pavement in this city, in Chesnut street, between Fourth and Fifth, that piece of paving is neither a good specimen of dressed stone pavements, nor will its durability be such as might have been expected, if proper care in its construction, foundation, and materials, had been duly observed.

To satisfy the necessary conditions, it would seem that the showing surface of dressed stone paving, ought to bear to the horizontal dimensions of the hoofs of horses, a relation sufficiently close to secure a foothold, and avoid slipping; whilst, at the same time, the block should have sufficient bearing surface, should be incapable of tilting under a passing wheel, and should have an extent of base equal to that of the surface exposed to the travel.

The size established by the practice of continental Europe, may, perhaps, be regarded as a close approximation to the best dimensions possible, though slight departures from it horizontally, keeping the depth uniform, and maintaining regular courses, would not impair the character of the pavement, whilst the allowance of some little latitude in the superficial dimensions, would certainly be promotive of economy in getting out, and preparing the stone blocks.

It has sometimes been proposed to form the stone blocks into oblique prisms, as well as into some other shapes, but upon this point we have no hesitation in declaring the opinion, *that all the stone ought to be rectangular prisms,* as we can perceive no advantage in the figures of the other solids suggested, which would be at all commensurate with the trouble and expense of forming them.

In laying a dressed stone pavement, it is important that the joints should not be more open than those of masonry usually are, or, in other words, the stone blocks should not be allowed to set a wider joint, than from three-sixteenths to one quarter of an inch.

The advantage of a closely jointed pavement, over one that is not so, is well shown by the first fifty feet of the stone pavement recently laid in Chesnut street, east of Fifth, which portion certainly exhibits a decided superiority over the remaining pavement in that square, though its joints are wider than we should prescribe.

Whilst the noise of vehicles passing upon a well dressed, and closely

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serious apprehensions need be entertained, that pavements with joints of the size we recommend, will be too smooth, as we have no reason to believe that horses would often slip upon their surfaces, if stone of a suitable quality be used.

Sir Henry Parnell observes upon this point, "that it is supposed by some persons, that if the streets were paved in the way proposed, (that is to say with *dressed stone)* their surface would be too smooth for horses to go safely over them; but this supposition is not well founded, except when that kind of stone is used which becomes polished by wear."

"Scotch granite, and some other kinds of stone, do not become polished, and, therefore, pavements made with them, will never have so smooth a surface as to be unfit for horses. A horse properly shod will seldom slip on a pavement, or fall, unless when thrown down by being turned too short, or other careless management."

In support of these observations, it may be remarked, that on the well dressed pavements of Vienna, and other European cities, a dangerous slipping of horses occurs so rarely, as not to form a valid practical objection; though it must be admitted, that in the nature of things, a certain degree of slipperiness, is inseparable from the smoothness of all good pavements.

Finally, with regard to pavements of dressed stone, we have, in substance, concluded—that they ought to be laid upon a foundation formed by another pavement, as is the custom in Paris—that the stone blocks should be disposed diagonally at angles of 45° with the axis of the street—that these blocks should approximate closely to a cube of eight inches side, or be parallelopipeds nearly cubical—that none of the joints between the blocks, when set, should be allowed to exceed three-sixteenths, or a quarter of an inch in width—and that the depths of all the blocks should be strictly uniform.

(To be continued.)

Report on Bisssell's Pneumatic Car or Carriage Spring.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination, the Pneumatic Car or Carriage Spring, invented by Levi Bissell, of Newark, New Jersey, REPORT:

That this spring is constructed with a cylinder closed at both ends, and charged with condensed air, which is acted upon by a piston. The cylinder is charged by a force-pump through a small opening in the upper head, which is closed by a valve opening inwards. The piston is of solid cast-iron, with a stem, or rod, passing through a stuffing-box, in the lower head, into a seat, or socket, on which the spring acts. The packing of the piston consists of a leather cup of the exact diameter of the cylinder, and of about two inches in depth, resting on its upper surface, and secured to it by a circular cast-iron plate, and a nut screwed on the upper end of the piston rod. This

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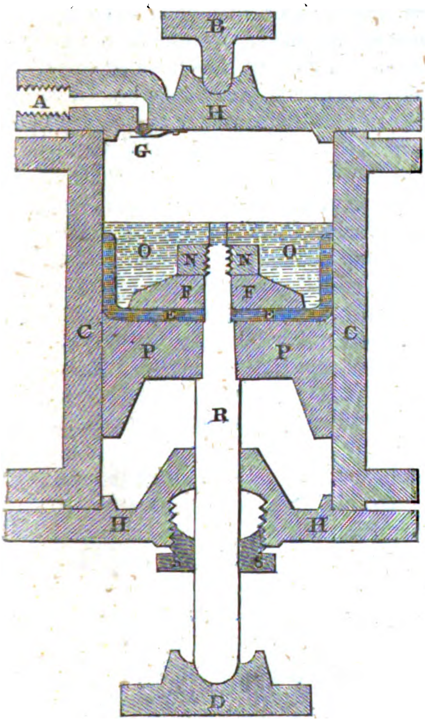
quantity of oil—say two inches in depth—to make the piston air-tight. The weight supported by the spring rests on the centre of the upper head of the cylinder. The spring submitted for examination, was one of four designed to support an eight-wheeled passenger car, of about ten tons weight, including its load. The cylinder was of cast-iron, six inches calibre, ten inches long, and three-fourths of an inch in thickness.



A, opening to attach air-pumps.
B, post sustaining load.
C, cylinder.
D, seat for piston-rod.
E, leather cup-packing.
F, cast-iron follower.
G, valve and valve-spring.
H, H, cylinder heads.
N, nut to secure packing.
O, oil and white lead.
P, piston.
R, piston-rod.
S, stuffing-box.

Springs of this description, made by Mr. Bissell, have been in use on the railroad cars running between Philadelphia and New York, for more than one year, and, the committee understand, have given entire satisfaction to the officers of the railroad company, and the traveling public. The difficulty originally and generally anticipated in their use, viz.,—the escape of the air from the cylinder, under a pressure of from two to four hundred pounds per inch, has not been realized—on the contrary, some of those in daily use have retained the air for upwards of five months, and remain in perfect order.

The arrangement of this spring is, undoubtedly, ingenious, but the committee feel bound to state, that it cannot be regarded as a novel invention. It is almost identically the same as the *Pneumatic Railroad Carriage Spring, Railway Buffer, and Elastic Drag*, in-

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vol. xxxi., p. 423. Mr. Burstall employed a cylinder, inclosing condensed air in a flexible sack, which was acted on by a piston in the same manner as that of Mr. Bissell. Mr. Stephenson, the celebrated English engineer, also employed cylinders with solid pistons, which acted against the water and steam, on his locomotive steam engine boilers *as springs,* as far back as 1814; descriptions and drawings of which can be seen in almost every work published upon railroads since that date. Mr. Robert Bowman, of Scotland, also invented a similar contrivance, for the purpose of stopping, or checking, chain cables of vessels, in 1825. It consisted of two cylinders fixed parallel to each other on the deck of the vessel, that were charged with condensed air by a force-pump, and were acted upon as a spring by pistons;—a description and drawing of which can be found in Newton's Journal of Arts and Sciences, vol. ii., p. 179. Mr. Robert Mallet, of England, also patented a similar contrivance in 1836, which he describes in vol. xxxvi. of the London Mechanics Magazine, p. 212. In his description of his improvement, he speaks of having used *a leather cupped packing, containing oil, or water, to make it air tight.* Mr. Mallet preferred water to oil, because it would not penetrate the leather under pressure, as readily as oil. Mr. Bissell prevents it, by a mixture of white lead with the oil. See also a description of Church's Air Spring, in Newton's (London) Journal of Arts and Sciences, vol. ii., conjoined series, p. 97 and 98, which is [identical] with Mr. Bissell's spring in almost all its details.

The committee award much credit to Mr. Bissell, for the energy and patience with which he has introduced, and put in use in this country, a valuable, though, not a novel, improvement. Mr. Bissel obtained a patent for his springs, which is dated the 11th of October, 1841.

By order of the Committee,

October 13*th*, 1842. William Hamilton, Actuary.

Civil Engineering.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 80.]

LECTURE XIII.

In continuation of the observations on *Railway Estimates,* which had been commenced in the last lecture, Mr. Vignoles observed that, having therein gone fully into the items of *construction* of railways, he had only glanced at the very necessary provision to be made for the efficient *working* of them—viz., the *Station and Carrying-establishment,* upon which he would say a few more words, for it was mostly under this head that the chief causes—or, rather, the chief excuses—for extra expenditure, or excess of estimates, had arisen. Properly speaking, this item, so costly, and yet so indispensable, should be taken as falling on a railway company, not as proprietors of the road, but as carriers—the distinction being, that if the railway was

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lic convenience, and generally necessary arrangements, did not make it imperative, or, at least, highly desirable, that the railway companies should be carriers (of passengers, at all events,) the expense of stations, and carrying establishment would not fall on them, though they must still be incurred by some parties, before the railway can be brought into profitable operation; nevertheless, the public, who are to use, and be benefited by the road, having, after all, to pay in one shape or another, are greatly interested in a proper expenditure, any excess of which is sure to be felt in increased charges, or in diminished accommodation, until the grievous expenditure of a rival line is introduced. In analyzing the cost of *Stations*, it is obvious that the land always forms a prominent item, for, being near towns and populous places, it is to be bought by the yard, and not by the acre—building land, villa land, &c. &c., instead of mere fields. Hence, it will not be surprising, if it is found that the cost of the land, for the stations only, on many of the great lines, has amounted to as much as one-third of the whole cost of land for the railway. The *buildings* erected at stations may be divided into three classes—those for the accommodation of the passenger traffic—those for the goods, minerals, &c.—and those for the repair and maintenance of the engines, carriages, &c. At principal towns, therefore, large and distinct establishments must be erected; and, on long lines, a principal central depot for the engines, is often required in addition. At the minor and road stations, the whole may be grouped together under one roof. In no department of expenditure, have so many differences, and so much useless extravagance in construction and arrangement, been displayed, as in the buildings at stations; and hundreds of thousands of pounds have been absolutely thrown away, from want of sufficient forethought and consideration, and by erecting enormous masses of buildings, either at the wrong places, or in an injudicious manner. It was better to wait until the character of the traffic was ascertained, before making such expensive permanent establishments, and then increase the accommodation by degrees. As an example of a moderate expenditure under this head, Mr. Vignoles mentioned some particular instances, and went somewhat into detail. At the terminus of a railway in a manufacturing town, with 80,000 inhabitants, there had been an expenditure of £9,500, for the passenger buildings, sheds, &c. &c.; £5,500, for goods' warehouses; about £2,000, for the mineral traffic; and about £3,000, for fixtures, turnplates, &c.—say, in all, about £20,000, exclusive of the land, which had amounted to a very large sum, upwards of £13,000, including a good deal of spare space, existing buildings, &c. &c. At a smaller town on the line, but with some extent of goods traffic, the cost for passenger buildings, sheds, &c., was £2,500; for merchandize accommodation, £3,500; turnplates, fixtures, tools, &c. &c., £1,000; land about £3,000. On the same railway, the cost of six or seven various minor road stations, including water tanks, coke, and engine sheds, tools, &c., was £3,500; land about £1,500; sundries on the whole line about £1,000—being a gross expenditure of £50,000 on station, land, and buildings, for a line of about twenty-two

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miles, which is at the rate of £2,273 per mile; and the corresponding carrying establishment of engines, tenders, &c. (for passenger traffic only), was about £19,000; for passenger carriages of three classes, horse-boxes, trucks, &c. &c., about £13,000, (the wagons for merchandize, coal, &c., as well as the engines, &c., being provided by carriers on the line, who provided their own carrying stock); and the necessary buildings for repair, and maintenance of engines, carriages, &c., with tools, fixtures, &c. &c., about £12,000—making a gross cost of £44,000, or £2,000 per mile. The whole of this concern having been arranged with the strictest regard to economy, may be taken as a fair average, and it will be safe to say, that £4,000 per mile, for an effective carrying establishment, with the necessary stations, is a moderate sum. For lines of less traffic, if of considerable extent—as, for instance, say for some of the long lines from the present railway termini in the north of England, to either of the principal towns in Scotland, a smaller amount might be sufficient; but Mr. Vignoles considered that it would be unwise to estimate a smaller expenditure than that of £3,000 per mile, for *Stations and Carrying-establishment*, on a line to be worked by locomotive engines, and it would be much safer to take £4,000; on either of these sums, £1,500 per mile for the locomotive stock and buildings must always be estimated, and about £500 per mile for the carriage department—leaving from £1,000 to £2,000 per mile for the stations, according to the extent of accommodation; keeping the instances of the extraordinary outlay on some of the principal railway lines as examples to be avoided, and not to be imitated, or referred to, as necessary.

Under the last head of *Management*, came all the various and miscellaneous items of expenditure, between the first concoction of the project, to the closing of the capital account. The preliminary expenses of examining the ground, leveling, surveying, maps, &c., and all the formalities in the engineer's department, to enable application to be made to Parliament; the ascertainment of the traffic, revenue, traveling, and other expenses of various kinds, &c. &c., generally undertaken by the secretary; the valuation of land, &c., by the surveyor; the collection of the names of the owners and occupiers, notices to them, applications for their assents, &c.; and the management of the bill throughout all its stages, falling to the charge of the solicitor. All these must be incurred before a spade was put into the ground, and had heretofore varied from £500 to £1000 per mile, according to the facilities afforded, the opposition encountered, the length of the line, &c. In future estimates, it was to be hoped this item might fairly be put, as not exceeding the smaller of these sums. Then came the setting out of the line, the detailed levels and surveys, and all the office work of the engineer, until the works are put into the hands of the contractor. The minute valuations of the property to be taken, and the juries, references, conveyancing, stamps, and all the various legal steps, until the company are put into full possession. Then the office establishment for regulating all the financial and ministerial affairs, and the temporary arrangements, police, lawsuits, and legal and illegal charges of all kinds, taxes and rates, interest and commission to agents and brokers, traveling expenses, salaries, and

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the aggregate, amount to a large sum. The whole of the outlay thus coming under the head of *Management*, has varied from 5 to 10 per cent. on the gross cost of the railways hitherto executed, according to their extent, and the amount of capital embarked, and especially according to the degree of vigilance exercised to keep down expenses, which depends chiefly on the director, or secretary, or under whatever name the acting manager of the company may superintend. Judging from the examples past, and the deep impression which has been made on the public mind, of the necessity of economy in every department, Mr. Vignoles thought 5 per cent. might be estimated hereafter, unless the lines were very short, and the capital small.

In recapitulation, the Professor observed, that the young engineer should always keep in view, for his estimates, the preceding great divisions of the cost—viz., *land*, including the damages, and fencing—*earthwork*—*works of art* (bridging and masonry, &c.)—*upper works* (the permanent railway proper)—*stations and carrying establishment*—*management*—and having, in his first estimates, allowed amply for each of those items under their several heads, he should add at least 10 per cent. for unforeseen contingencies. Some of the preceding items would be common to almost all railways, and others, of course, would vary greatly, according to local circumstances, chiefly regulated by the amount of earthwork; for, as that is heavy, so the works of art become costly, since the works of art are merely to restore the existing communications of the country, and the natural, or artificial, water-courses, and drainage to their state before disturbed, or as near as may be, and that to an extent in exact proportion to the civilization, and improvement of the country, to enforce all which stringent clauses are inserted in the Acts of Parliament, and plenty of persons are always on the watch to enforce them. Mr. Vignoles observed, that the land, leveling of the ground, and restoring of communications, might, on the average, including contingencies, extra land, &c., be taken as forming about 50 per cent. on the total outlay of railways hitherto executed. But, referring to the items the Professor had gone over in detail in previous lectures, it appeared that, when proper economy and circumspection were used, the necessary cost of the railway proper—that is, the necessary quantity of land for the road only, a good substantial set of upper works for a double way, and a complete and effective carrying establishment—might, and had been, obtained for £10,000 per mile. All beyond is expenditure to obtain gradients, more, or less, perfect, and Mr. Vignoles thought that the great error all engineers had hitherto committed, the cardinal mistake—of which he himself was far from guiltless—was, seeking to make railways, intended, as they were, chiefly for passengers, *too perfect*—that is, of cutting down hills, and filling up valleys to too great an extent, on the erroneous supposition that the engines were always to carry *maximum* loads, which was very seldom the case, and never would be so on lines at a distance from the metropolis, particularly such as the lines into Scotland, previously mentioned. In short, the Professor insisted that the engineer should, in such instances, and for

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the cross railways, which he yet hoped might be introduced, make the gradients and curves much less theoretically perfect; and that the amount of expenditure, beyond the above stated necessary one of £10,000 per mile, should be reduced to the very *minimum;* and he considered that henceforth an average of £15,000, or £16,000 per mile, and a *maximum* of £20,000, or, in very extraordinary cases, indeed, of £25,000, should be looked to for the construction of double lines of railway in any country, but that in most cases, of light traffic, and consequent adaptation of gradients, for single lines, a sum of from £7000 to £12,000 per mile would be the limit of total expenditure. Mr. Vignoles concluded by observing, that the preceding abstracts were deduced from very detailed accounts, which had been arranged on a uniform system, and kept from the very commencement of each undertaking, so as to be available at any time during the progress of the works, to show the exact state of the expenditure; and had been finally worked out to the nearest thousand pounds, as above. And the Professor expressed his great hope and expectation that this example would be followed, and that similar accounts would shortly be forthcoming, of the corresponding items of cost on all the principal railways in this and in other countries, more especially where complaints of improper excess of expenditure over estimates (well or ill-founded) had been charged, for the publication of such accounts—and the more in detail the better—would be the most complete defence of the directors, and the most satisfactory explanation from the engineer, and alike valuable, as statistical information to the country—as salutary guidance to the capitalist and speculator—and as valuable information and warning to the old, as well as to the young practitioner.

The preceding is a very brief outline of this interesting lecture, and the following, we believe, is a correct abstract of the cost of the two railways quoted by Mr. Vignoles.

COMPARATIVE ABSTRACT

Of the Cost of two Principal Lines of Railway, under the general heads of Expenditure, as deduced from the very latest accounts of Actual Expenditure, brought out to the nearest round numbers:

MIDLAND COUNTIES RAILWAY. [57¾ MILES.]

Heads of Expenditure.	— — —	Pr. ct. whole cost,	C't. pr. Mile £	Total Cost £
Railway land, and damages,	(790 acres)	12	3463	200,000
Fencing, gates, roads, &c.,		3½	1004	58,000
Earth work,	(5,700,000 cubic yards)	18½	5455	315,000
Works of art, of all kinds,	[tons]	15	4364	252,000
Iron rails and chairs,	Upper Works £215,000—(17,670)	23	6822	394,000
All other materials, and labor,	179,000			
Station land, and damages,	Stations and carrying establishment. £ 51,000	21	6147	355,000
Buildings, fittings-up, &c.,	168,000			
Engine, &c. stock,	75,000			
Carriage, &c. stock,	61,000			
Management, law, interest, &c		7	2182	126,000
Totals,	— — —	100	29,437	1,700,000

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NORTH UNION RAILWAY. [25 MILES.]				
Heads of Expenditure.	— — —	Pr. ct. whole cost	C't. pr. Mile. £	Total Cost. £
Railway land, and damages,	(320 acres)	8	2000	50,000
Fencing, gates, roads, &c,		3⅓	800	20,000
Earth work,	(2,900,000 cubic yards)	20⅓	5000	125,000
Works of art, of all kinds,		20⅓	5000	125,000
Iron rails and chairs, All other materials, and labor,	Upper works £68,000 (6885 tons.) 62,000	21	5200	130,000
Station land, and damages, Buildings, fittings-up, &c., Engine, &c. stock, Carriage, &c. stock,	Stations and carrying establishment. £18,000 48,000 20,000 14,000	16⅓	4000	100,000
Management, law, interest, &c.		10	2400	60,000
Totals,	— — —	100	24,400	610,000

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

American Steam Excavator of Otis, or the Yankee Geologist.

Having availed himself of a recent invitation from Messrs. Eastwick & Harrison, Engineers and Machinists of this place, to view *three* well constructed steam excavators, which these gentlemen have just completed for the Emperor of Russia, and are about to ship for that country, to be there employed upon the extensive railways about to be commenced; the writer collected a little information relative to them, which may, possibly, interest some of the readers of this journal.

These steam excavators, as devised by the late ingenious Mr. Otis, are really high efforts of inventive talent, and will do credit to American ingenuity wherever they are seen and used.

But *seven* of these machines have yet been built, the whole of which, excepting the first, having been made by Messrs. Eastwick & Harrison; the first was partially completed at various workshops, under the direction of the inventor, Mr. Otis, in person; but finding some diffiulty in organizing and fitting up so complicated a machine, by this method of proceding, he fortunately placed it in the hands of Messrs. Eastwick & Harrison, who skilfully perfected the details, and gave such good proportions to the several parts, that all the machines constructed, including the experimental one, have proved, in practice, to be completely successful, though it has been deemed advisable to give augmented strength to those recently built.

The present price of these machines in Philadelphia, is $6,500, but in consequence of the patterns being now on hand, and of the complete system, introduced by these excellent mechanics, into the manufacture of this new machine, it seems probable that Messrs. Eastwick & Harrison may, hereafter, be able to furnish them even at lower rates.

The high pressure steam engine, which operates each of the excavators viewed by the writer, has a single cylinder, of 9 inches in

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diameter, and 1 foot stroke, the speed of the piston being usually about 200 feet per minute, when the pressure on the safety-valve is 100 lbs. per square inch; and, consequently, in the ordinary mode of computing small high pressure engines, it will realize ***about fifteen horses' power.***

From the large amount of work which has already been done by some of these machines, in an active service of several years, there seems to be but little doubt, that one of them, in a common working day, ***can dig and load from*** 800 ***to*** 1200 ***cubic yards of average earth.***

The scoop will contain about a cubic yard of earth measured in the cut, and a common day's work is 1000 full dips of the scoop, but 1200, or 1300, have frequently been made; we may, therefore, from our present information, set down as a certain average work, 1000 ***cubic yards excavated, and loaded upon cars per day.***

It will be borne in mind, that the "*yankee geologist*" merely does the digging and loading, or the getting and filling, ***the transportation, dumping, trimming, &c.***, remaining the same as though the cars had been loaded by the labor of men, in the usual manner.

In heavy excavations of common earth, where a large number of men have been employed, the writer has often observed, that the work of hands rarely averaged more than 12½ cubic yards, loaded into a cart per day, per man, the earth being previously ***loosened*** by the pick, or plough.

Now, taking the wages of men at ***one dollar*** per day, including all charges, and putting the ***loosening*** at the moderate estimate of one cent per cubic yard, the actual cost of digging and loading, in an average case of heavy earthwork, would be ***about nine cents per cubic yard.***

We will now, from the best information before us, frame an estimate of the probable cost of excavating and loading ordinary earth in heavy cuts, by the aid of the "*yankee geologist.*"

Probable Annual Charges.

Interest on cost at 6 per cent. on $6,500,	$ 390
Renewals, wear and tear, say 25 per cent.,	1,625
One cord of wood per day, at $4, for 300 days,	1,200
Oil and packing, $1.50 per day × 300 days,	450
Two machine tenders, at $1.50 per day, for 300 days,	900
Eight car tenders, at $1 per day, for 300 days,	2,400
One overseer, for 300 days, at $2 per day,	600
Total expenses per annum, say,	$ 7,565

Now, in 300 working days, this machine would, from the data given, excavate and fill into cars, about 300,000 yards; and hence, it would appear, that where it is able to work 300 days in a year, this machine would dig and load ordinary earth, at the extraordinary low rate of two and a half cents—or, allowing for contingencies, say ***three cents per cubic yard;*** **which is only about one-third of what it would cost by manual labor.**

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Such is the surprising result, to which the writer has been led by the information laid before him, by Messrs. Eastwick & Harrison, and which, if it be even approximated to, in the general continuous working of these steam excavators, *will, inevitably, enable them to banish manual labor from the digging and loading, in all heavy earthworks.* M.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Mr. Mallett's Close Breast for an Overshot Water-Wheel, not New.

In the July number of the Journal of the Franklin Institute, the writer has observed an abstract of some experiments made by Mr. Mallett, to prove that an advantage of from "8 *to* 11 *per cent.*" may be obtained by the use of a close breast to confine the water upon the lower quadrant of an overshot water-wheel.

These experiments seem to have been announced to the Institution of Civil Engineers, by Mr. Mallett, and discussed by that intelligent body, as though the application of a close breast, in the manner referred to—or, at the least, the valuation of its advantages—had been both new and original with Mr. Mallett; and though we will not pretend to say that the latter was not the case, we cannot repress a feeling of surprise, that such a well read man should have overlooked the fact, that the Franklin Institute, upon a much superior scale to his, had, long since, made with full sized water-wheels, all the experiments necessary to settle conclusively, every point relative to *"the coefficient of laboring force in overshot water-wheels, &c.,"* which he has attempted to illustrate, by his little tin models of 25 and 33 inches in diameter.

It was for the very purpose of obviating the just objections urged against the results obtained by Smeaton, Bossut, Banks, and others, from *little models* of water-wheels, that the extensive experiments of the Franklin Institute were undertaken.

In the face of these, and of that able series of trials made by Morin, on water-wheels actually driving heavy works in France, are we now to return again to the imperfect conclusions derived from insignificant models? We anticipate the answer of well trained mechanics every where to be NO!

It would have been singular, indeed, if an experiment so obvious, as that of applying a close breast to the lower acting quadrant of an overshot water-wheel, should have escaped the attention of the committee of the Franklin Institute; and, accordingly, we find their conclusions upon this point, recorded in vol. i., 3rd. series, of this journal, p. 368, where they clearly show, with regard to the "*use of a close breast with an overshot water-wheel,*" that the ratio of effect to power, "appears to be in favor of the use of the breast, in the proportion of .751 to .702, or of 1.07 to 1.00, under the average of heads from 0.25 to 3.75 feet, and of head and fall from 10.5 to 14.0 feet."

In conclusion, we recommend these prior experiments to Mr. Mallett's consideration, as furnishing a much safer basis for practical operations, than can possibly be the case with his own. M.

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On the causes of the unexpected breakage of the Journals of Railway Axles; and on the mean of preventing such accidents by observing the Law of Continuity in their construction. By William John Macquorn Rankine, Assoc. Inst. C. E.

The paper commences by stating that the unexpected fracture of originally good axles, after running for several years, without any appearance of unsoundness, must be caused by a gradual deterioration in the course of working; that with respect to the nature, and cause of this deterioration, nothing but hypotheses have hitherto been given: the most accepted reason being, that the fibrous texture of malleable iron assumes gradually a crystallized structure, which being weaker in a longitudinal direction, gives way under a shock, that the same iron, when in its fibrous state, would have sustained without injury.

The author contends that it is difficult to prove that an axle which, when broken, shall be found of a crystalized texture, may not have been so originally at the point of fracture, although at other parts the texture may have been fibrous.

He then proceeds to show that a gradual deterioration takes place in axles without their losing their fibrous texture, and that it does not arise from the cause to which it is usually attributed.

From among a large collection of faggoted axles which had broken after running between two and four years, five specimens were selected, of which drawings are given, representing the exact appearance of the metal at the point of fracture, which in each case occurred at the re-entering angle, where the journal joined the body. The fractures appear to have commenced with a smooth, regularly formed, minute fissure, extending all around the neck of the journal, and penetrating, on an average, to a depth of half an inch. They would appear to have gradually penetrated from the surface towards the centre, in such a manner that the broken end of the journal was convex, and necessarily the body of the axle was concave, until the thickness of sound iron in the centre became insufficient to support the shocks to which it was exposed.

In all the specimens, the iron remained fibrous; proving that no material change had taken place in its structure.

The author then proceeds to argue, that the breaking of these axles was owing to a tendency of the abrupt change in thickness, where the journal met the shoulder, to increase the effect of shocks at that point; that owing to the method of manufacture, the fibres did not follow the surface of the shoulder, but that they penetrated straight into the body of the axle; that the power of a fibre to resist a shock being in the compound ratio of its strength and extensibility, that portion of it which is within the mass of the body of the axle, will have less elasticity than that in the journal, and it is probable that the fibres give way at the shoulder, on account of their elastic play being suddenly arrested at that point. This, he contends, would account for the direction of the fissure being inward towards the body of the axle, so that the surface of the fracture was always convex in that direction.

that the fibre shall be continuous throughout; the increased action at the shoulder, would thus be made efficient in adding strength to the fibres without impeding their elasticity. Several axles having one end manufactured in this manner, and the other by the ordinary method, were broken: the former resisted from five to eight blows of a hammer, while the latter were invariably broken by one blow.

The vibratory action to which axles are subjected is then considered, and it is contended, that at the place where there is an abrupt change in the extent of the oscillations of the molecules of the iron, these molecules must necessarily be more easily torn asunder; and that in the improved form of journals, as the power of resisting shocks is increased by the continuity of the superficial fibres, so is the destructive action of the vibratory movement prevented by the continuity of form.

The paper is illustrated by five drawings, showing the section of the journals of broken axles, and their appearance at the moment of fracture.

Mr. York agreed with Mr. Rankine in several points, and stated, that since the last meeting, he had made a series of experiments, which confirmed his opinion relative to the vibration in solid railway axles being arrested, when the wheels were keyed on tight. In all such cases, where the vibration was checked, fracture would, he contended, be more likely to ensue, but with hollow axles, there was very little difference of sound when struck, and no diminution of strength, after keying on the wheels; this he attributed to the regular distribution of the molecules in the metal of the hollow cylinder.

Mr. Parkes coincided with Mr. York's opinion, and he believed that hollow axles would eventually supersede solid ones, particularly if they had sufficient rigidity for resisting flexure. Their faculty of transmitting vibration more readily was in their favor; it was well understood, that in pieces of ordnance, and musket-barrels, great regularity of proportion in the metal was requisite, in order to insure the equal transmission of the vibration, caused by the sudden expansion of the metal at the moment of the explosion, and unless the vibration was regular, the barrel would burst, or the ball would not be correctly delivered.

Mr. Greener, of Newcastle, among other experiments, turned the outside of a musket-barrel to a correct taper, and fixed tight upon it at given intervals, several rings of lead, 2 inches in thickness; on firing a charge of 4 drachms of powder, he found that all the rings were loosened, and had all expanded regularly in their diameter.

It was a well known fact, that cannon seldom, or never, burst from continuous firing; such accidents, unless they arose from peculiar circumstances, generally occurred in consequence either of inequality in the nature of the metal, or irregularity in its distribution; to the latter cause must be attributed the bursting of the "Mortier monstre," before Antwerp, and of a large gun which was proved at Deal, some time since; this latter gun burst at the third discharge, after delivering the ball better than on either of the previous discharges; it was

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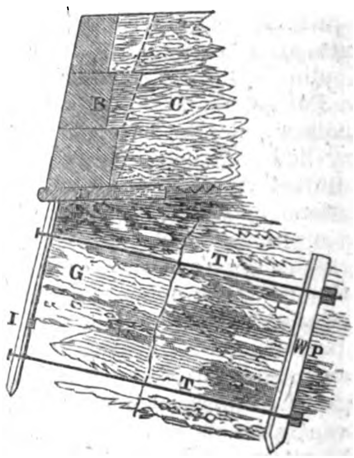
after the discharge, and also because the thickness of metal was not well proportioned, whereby the vibration was unduly checked, the cohesion of the molecules of the metal was destroyed, and the gun fell into several pieces, without any of them being projected, as they would have been by the usual effect of an explosive force.

The most practical millwrights were well aware of the superiority of hollow shafts, and they were frequently used, as they were more easily kept cool than solid ones, especially at high velocities, when shafts were peculiarly liable to injury from percussive force, or from a series of recurring vibrations.

Lond. Mechanics' Mag.

Greenwich Pier.

We abstained last month from giving any account of the failure of this pier, which took place on 16th of May last, as we had not then an opportunity of personally inspecting it, or of ascertaining its construction; we have since been favored by our valuable correspondent, O. T., with the following observations, and sketch of the pier. He observes, "the failure of Greenwich pier is not a matter of surprise to parties who understand the practical construction of such works. The immediate cause of the failure was dredging in front of the piles, after the contractor had left the works, and the arrangement of the piles being faulty, as regards construction; the upper part is composed of brickwork in cement B, 18 feet high, and 14 inches thick at top, capped with granite 1 foot thick, backed with concrete, C, and standing upon a foundation of Yorkshire stone landings, L, laid on a small quantity of concrete, with a substratum of foul gravel, G. The landing, in front, rests on a row of cast iron piles, I, P, 25 feet long, and 5 feet apart,



grooved to admit between them three cast iron plates, each 6 feet in height, these iron piles were fastened by four, or two, pair of wrought iron land ties, T, 2 inches square, to wooden piles, W, P, 18 feet long, and 12 inches square, driven in land at a distance of 25½ ft. from the front, and 5 ft. apart." The high water mark is about 4 feet from the top, and low water mark 22 feet below, or about 7 feet below the stone landing. From inquiry, we rather suspect the lower ties, as shown in the sketch, were not fixed, nor do we see how they could

superincumbent weight of the brickwork appears to have forced out the upper part of the iron piles to a considerable distance, and caused the brickwork above to slip down, and force out the iron plate; but, it is very difficult to say whether this is the real cause of the failure, for, until the ruins are cleared away, nothing positive can be stated.

Civ. Eng. & Arch. Journ.

Railway Axles.

A paper by Captain Handcock was read May 16th, 1843, describing a railway axle invented by him, which had been used for nine months on the Southampton Railway. The alterations consisted in making the journals of a conical form at the shoulder end, and at the outer end, a similar conical collar slides upon the journal, and can be forced forward by a screw collar at the extremity; the brasses are also conical at the entrances, following the parallel form of the journal, and meet in the centre within half an inch; they can revolve in the bored cast iron boxes when the friction upon the axle becomes excessive. It has been found that this form prevents the usual oscillation of the carriages, because, if the brasses wear, the conical collar is screwed up, and the lateral motion ceases; the wear and tear is diminished, and the saving of oil is very great: it was stated that one pint of oil had sufficed to lubricate all the axle-bearings of a six-wheeled engine, and a four-wheeled tender whilst running 924 miles; and that there was not any tendency to heat.—*Trans. Civ. Eng.*

Lond. Athenæum.

Unburnt Bricks from the Pyramids of Duskmoor, Egypt.

From the description by Mr. Perring, who brought them to England, it appeared that they were made from the alluvial soil of the Valley of the Nile, mixed up with chopped straw; that they were made with cavities in the sides like the modern bricks, and that the interior of the Pyramids was formed of *arches*, the bricks composing them, being either packed behind with pieces of flat pottery, or cut away to radiate equally from the centre. There existed at Thebes some extensive ranges of arches, of about twelve feet span, the bricks of which they were built bearing the name of Sesostris, and, consequently, they must have stood uninjured upwards of 3180 years; the arches were turned in concentric half-brick rings. Ibid.

Captain Norton's Lotus Floating Breakwater.

On a lake or pond where the lotus grows, Captain Norton had observed, that when there was a strong breeze, and waves on one side, on the other the water was comparatively smooth, resulting from the wind having no hold on the broad expanse of lotus leaves. He had also observed, after a storm at sea, the solid timbers of a wrecked vessel splintered in pieces by being driven against the shore, while a

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singularly ingenious model in the Polytechnic Institution, the expense of which would be trifling compared with others.

Polytechnic Journal.

Architecture.

The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 98.)

II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

The *buildings* required in cemeteries may next occupy our attention. A chapel, or chapels, are generally required, because some persons prefer the burial service read under cover, or this may be rendered necessary by the state of the weather. The size of a chapel, therefore, should be such as to afford seats for the ordinary number of attendants at a funeral, with an open area in the centre, of sufficient diameter to hold two or more coffins on biers; and, as it is a general custom in Christendom to carry a corpse with the feet before, the body being brought in, and set down on the bier in that position, is, after the service is over, taken up by men and turned completely round, so that the feet may be in advance before it is taken out of the chapel. In addition, therefore, to the space necessary for holding the bier and the coffin, there must be room for turning the latter completely round, either while on the bier, which has long handles for that purpose, or on men's shoulders. A circle 10 or 12 feet in diameter, or a square that would contain such a circle, will afford ample space for these purposes, and the remainder of the chapel may be occupied with the pulpit, desk, seats, &c.

In the chapels of some of the new London cemeteries, instead of biers for the coffins, there is a table, the top of which has one or two spaces, each of the width of a coffin, filled in with rollers, and the entire top of the table turns on a pivot. The coffin, or coffins, when brought in, are put on the table, by sliding them on the rollers; and, after the service has been performed, the table is turned round on its pivot, when the coffins being thus placed in the right position for going out, are carried away by the bearers. The rollers facilitate the sliding on, and drawing off, of the coffins, and the turning of the table, by means of the pivot, saves the most difficult and awkward portion of the labor performed by the bearers, who, when not much accustomed to it, are apt to stumble, and create alarm in the mourners lest the coffin should fall. When a bier-table of this kind is used, the area left for it need not exceed 8 ft. in diameter, which will thus save 4 ft. in the entire length, and the same in the breadth, of the chapel.

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A very convenient apparatus of this kind has been put up at the Kensal Green Cemetery. In the body of the chapel is a bier, in the form of an altar, about 8 ft. long, 4 ft. broad, and 4 ft. high, hung round with black velvet. The upper surface of this altar-like structure consists of a top for holding one or two coffins; and, to facilitate the putting on and taking off of these, this plate, or top, is furnished with rollers. After the desk service has been read, the top containing the coffin, or coffins, can be turned slowly round by machinery, operated on by a small movable winch handle on one side, which is done after the service has been read, when the interment is to take place in the open ground, or in the catacombs at a distance from the chapel; but, when the coffin is to be removed to the vaults under the chapel, there is machinery below, worked by a man there, on a signal being given, by ringing a small bell, by which the entire bier, and the coffin, or coffins, which may be on it, are slowly lowered into a central area in the vault beneath. The mourners having descended by a staircase much too small for a chapel so magnificent in other respects, the coffins are carried from this area to the vaults, which radiate from it in four directions, and occupy nearly an acre of ground. The machinery by which the bier is lowered, consists of two vertical male screws, worked by two female screws, or nuts, which are moved by means of two beveled wheels set in motion by a man turning a windlass handle. This machine, while it lowers the bier through the floor, moves at the same time two horizontal shutters, which gradually close the opening in the floor, as the coffin descends from the view of the spectators in the chapel; while, by the time they have arrived in the area below, the bier is already at the bottom, with the coffin on it, ready to be removed to the vault. The great advantage of using a screw movement for the descent of the bier, is, that the motion can never be otherwise than slow and solemn, and that it cannot run down in case of the handle being set at liberty. This admirable contrivance was invented and executed by Mr. Smith, Engineer, Princes Street, Leicester Square, the patentee of an excellent window shutter, and of several other inventions noticed in our *Encyclop. of Cott. Architecture.* The cost was about 400*l.* In the Norwood Cemetery the same object is effected by means of Bramah's hydraulic press, which raises and lowers the bier with the slightest possible noise, and with a degree of steadiness which cannot be equalled by any other machine. The cost is about 200*l.* There is one drawback, however, to this machine, which is, that during very severe frosts the water is liable to freeze; but this may be guarded against by shutting all the outside doors of the vaults, and by the use of stoves. In ordinary winters, however, the latter are unnecessary. This machine was put up by Messrs. Bramah, Prestage, and Ball.

The number of sittings need seldom exceed fifty, at least in the neighborhood of London, as it rarely happens that more than a fourth of that number attend a funeral. Whatever be the architectural style of the chapel, it ought to contain a bell, the ringing of which, when the hearse is approaching from the entrance gate to the chapel, may be considered as a part of the burial service. The bell ought to be

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barn, in the same manner as the chimney tops of a dwelling are characteristic of a human habitation.

The *entrance lodge* to a cemetery ought to comprise a room to serve as an office to contain the cemetry books, or, at least, the order book and register, and the map book, where, from the system of squares being employed, such a book is rendered necessary. In small cemeteries, and in common churchyards, where the sexton is also the clerk and registrar, all the books, and other documents, will be kept in a strong closet in this room; but, in large cemeteries, managed by a court of directors, the books are kept by a clerk in the cemetery office, in the town, or district, to which it belongs, and only an order book, and the register and map book, or duplicates of them, are kept in the lodge.

Vaults are commonly made under churches, or chapels, but in the large cemeteries they are also made in the open ground, in deep excavations descended to by stairs, and ranged on each side of a passage, or passages, which are lighted through iron gratings on the surface. One of the best examples, on a small and economical scale, is the public vault in the Abney Park Cemetery. The most classical situations for vaults, is in the face of a steep rocky bank, where they require no drainage, and can be entered without descending more than a few steps; such as occurs in the St. James' Cemetery, Liverpool; the Sheffield Cemetery; and the Cathedral, or Necropolis, Cemetery of Glasgow. Catacombs above ground, like those in the London and Westminster Cemetery, like some private tombs in the Kensal Green Cemetery, and like those in the new burying-ground attached to the old church at Brighton, are, in our opinion, in bad taste; since the general idea of burial, no matter by what mode, implies the descent of the body below the surface of the ground. Private vaults for the use of a single family, are commonly made of the width of two or three coffins, and of such a depth as to hold several placed one over the other, commonly with iron bars, or plates of stone between, so that no coffin may have more to bear than its own weight, and the air may be allowed to surround them, to prevent them from rotting. Sometimes each coffin is placed in a separate cell, and closed up with masonry.

Catacombs.—Sometimes the vault is divided into cells like bins in a wine-cellar, by vertical divisions of brick, or stone; and these cells are called catacombs, though the term is frequently applied to a vault, or crypt, not sub-divided into cells. Each cell, when the coffin is inserted, is hermetically sealed, by building it up with brickwork, or inserting a tablet of stone, or marble, inscribed with the name, age, &c., of the deceased. In the new London cemeteries, the cells, or catacombs, are frequently only closed with an open iron grating, the end of the coffin being fully exposed to view. In some cases the cells are literally shelves, and the entire side of the coffin is exposed, as in the West London Cemetery. Both of these modes are attended with gerat danger to the living; whether by the bursting of the lead cof-

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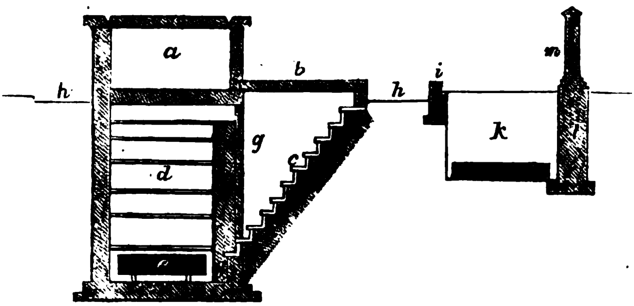
holes made on purpose by the undertaker under the brass plate, as already mentioned. When a private vault is formed on even ground in an open cemetery, steps are made for descending to it; and these steps are commonly covered by a flat stone, level with, or slightly above the surface; or in some cases, as where the steps are under a walk, or path, the stone is concealed under this. Over the vault is placed a monument of some kind, most commonly what is called a square tomb, as in fig 3.; in which *a* is the tomb, or superstructure; *b*, the cover to the steps; *c*, the steps; *d*, the catacombs, or cell; *e*, a coffin placed in the lowest catacomb, and sealed up at *f*; *g*, a door of slate, flag-stone, or iron; and *n*, the grass alleys. In this figure is also shown a common grave, in which *i*, is the foot-stone; *k*, the grave, containing a coffin at bottom; *l*, the basement wall to the head-stone; and *m*, the head-stone.

Fig. 3.



A *brick grave* is a substitute for a vault, and differs only from an ordinary grave in having the sides and ends of brickwork, or masonry, and in being covered with a large flat stone, technically, a ledger-stone. These graves are generally purchased and built by heads of families. Sometimes they are of the width of two coffins, but generally of one; and they vary in depth from 10 ft. to 20 ft., or upwards. When an interment takes place, the stone is loosened by levers, and removed by means of rollers; and, the coffin being let down as in common graves, the ledger-stone is replaced and cemented. The side walls are built concave next the grave, in order that they may act as arches against the exterior soil; and, in some cases, they are furnished with ledges which project 2 or 3 inches from each side, for retaining a flag-stone, or slate, between each coffin. When this flag-stone is securely cemented, the coffin below may be considered as hermetically sealed, though it is not very likely that this will be done so completely, as to prevent the ascent of the mephitic gas. In other brick graves no ledges are projected, but one coffin is prevented from resting on another, by inserting two bars of iron in the side walls, so as to support each coffin. When the coffins reach within 3 or 4 feet of the surface, the ledger is put on for the last time; and a putrid mass

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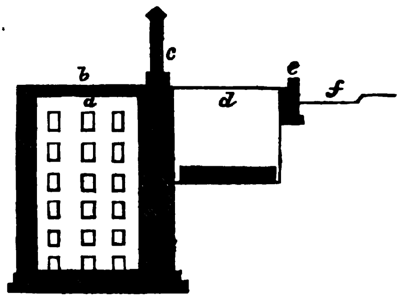
escape, probably for years, through such crevices as may be left, or as may occur from the action of the weather, or other causes, between the ledger and the side walls on which it rests. The proper mode would be to fill in the uppermost 6 or 8 feet of the grave with earth. The names of the interred are inscribed on the ledger, in the order of their interment; or a monument of some kind is erected on it, of such dimensions, and in such a position, that it can be removed in one piece with the ledger, without being loosened, or otherwise disturbed. In the Highgate Cemetery there are ledger-stones weighing, with their monuments, eight, or ten tons, which are removed all in one piece every time an interment takes place. The more common mode, however, is to place a head-stone as a monument, as shown in the section, fig. 4. In this section, *a* is the side wall of the grave, here shown with openings to permit the lateral diffusion of moisture and mephitic vapour; *b* is the ledger, or covering stone; and *c*, the headstone. At one end is a common grave *(d)* with its footstone *(e)*; and one of the two double green alleys, which form boundaries to the raised panel of graves, is shown at *f*.

Fig. 4.



Brick graves are also used as earth graves, and filled to the surface with soil every time after an interment has taken place. The openings for reinterments should, as we have already mentioned, never be sunk to a greater depth than within 6 ft. of the last deposited coffin; in which case no very great disturbance, or danger, from putrescence would take place, more especially in clayey, or loamy, soil, and when it is made a rule to ram the soil hard with a cast iron rammer, to the height of at least 6 ft. above every coffin as it is deposited.* When the last deposited coffin is within 6 ft. of the surface, the grave should be finally closed. Graves of this kind are not necessarily covered with a ledger-stone; they may be finished with a raised mound of earth, like a common earth grave, or the side and end walls may be finished with curb-stones a foot above the surface, and the interior left level, or planted with flowers. After the last interment, a cy-

* Family graves, in some of the new cemeteries, are made from 12 ft. to 30 ft. in depth. We lately saw one in the Norwood Cemetery, which had been originally 20 ft. deep, and had one coffin deposited in it, after which it was filled in to the surface with soil. It was, at the time we saw it, being opened to the depth of between 18 ft. and 19 ft., and the smell proceeding from the earth brought up, was, to us, intolerable. This, and numerous other cases which we have witnessed, or which have come to our knowledge altogether, independently of the Parliamentary *Report on the Health of Towns*, for 1842, or Mr. Walker's *Gatherings from Graveyards*, have strongly impressed us with the necessity of a law to limit the proximity of one coffin to another in graves in which more than one interment is made, unless, as before observed, the coffins are put in on the same day.

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press, or other tree, or a strong-growing herbaceous plant, might be planted in the centre. The walls of graves of this sort should be built with numerous openings, as in fig. 4, to permit the lateral diffusion of the products of decomposition, and of the natural moisture of the soil.

Earth graves are of two kinds: *private graves*, in which only one body is deposited, with, or without a monument; and *common graves*, in which several bodies are deposited, of poor persons, or paupers, for whom no monument is ever put up, except a mound covered with turf, but which ought always to be marked with a stone number for reference, and to prevent all risk of their being opened again at any future period.

To be Continued.

Mechanics and Chemistry.

On certain improvements on Photographic Processes described in a former Communication, and on the Parathermic Rays of the Solar Spectrum. By Sir J. F. W. Herschel, Bart., K. H. F.R.S., &c.; *in a letter addressed to S. Hunter Christie, Esq., Sec. R. S.*

Dear Sir,—I beg leave herewith to submit for your inspection, and that of the Royal Society, a series of photographic impressions, illustrative of the chrysotype, cyanotype, and other processes, an account of which is given in the postscript to my last paper on that subject, which has, by permission of the president and council, been appended to the original in its printed form subsequently to the termination of the session. In the interval which has since elapsed, besides the discovery of other photographic novelties (which may form the subject of future communications), I have been enabled materially to improve some of the processes there described; and these improvements, with a few remarks on some other points treated of in that paper, in relation to the processes in which the thermic rays are concerned, are now subjoined.

The positive cyanotype process described in Arts. 219, 220, of my papers though beautiful in its effect (especially during the first few minutes of the appearance of the picture), is very precarious in its ultimate success, owing to causes there detailed. The remedies proposed are also only occasionally and partially successful, and, in consequence, this process, though exceedingly *easy* in its manipulations, could not be recommended as practically useful. After trying a vast variety of means to overcome these obstacles to its success, I have succeeded at last, by the simple addition of corrosive sublimate to the ammonia-citrate of iron, with which the paper is prepared. The improved process, therefore, may be thus stated. Mix together equal measures of a saturated cold solution of corrosive sublimate, and a solution of ammonio-citrate of iron, one part by weight of the salt to eleven parts of water. No immediate precipitation takes place, and before any has time to do so, the mixture must be washed over paper, (which should have rather a yellowish than a bluish cast,) and dried. It is now ready for use, and I do not find that it is impaired by keeping. To use it, it must be exposed to the light till a faint, but yet

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withdrawn, it is to be brushed over as rapidly as possible with a broad flat brush, dipped in a saturated solution of prussiate (ferrocyanate) of potash, diluted with three times its bulk of gum-water, so strong as just to flow freely without adhesion to the lip of the vessel. All the care that is required, is, that the film of liquid be very thinly, evenly, and, above all, quickly, spread. Being then allowed to dry in the dark, it rarely fails to produce a good picture. And what is very remarkable, it is *ipso facto* fixed as soon as dry, so, at least, as not to be injured by exposure to common day-light, immediately; and after a few days' keeping it becomes entirely so, and will bear strong lights uninjured. By long keeping, details, at first barely seen, come out, and the whole picture acquires a continually increasing intensity, without, however, sacrificing distinctness; and by the same gradations, its color passes from purple to greenish-blue. Some experience, to be acquired only by practice, is necessary to determine the proper moment for withdrawing the photograph from the action of the light. If it be over-sunned, only the darker shades appear; if too little, the whole, though beautifully perfect in the first moments of its appearance, speedily runs into an indistinguishable blot.

The principal obstacle in the way of the employment of gold and silver, as photographic ingredients for the production of negative models, to be used for retransfers, so as to multiply positive copies, arises from the want of absolute opacity in these metals, or their oxides, when in a state of minute division. The same objection does not apply, or applies with much less force, to mercury, which (probably owing to its fluid state, which prevents its particles from acquiring that excessive tenuity which a laminated form would admit, by reason of their capillary forces contracting each separately deposited particle into a sphere) is one of the most opake substances (after carbon) known. I find that this high degree of blackness and opacity may be induced on a mercurial photograph prepared as in Art. 228, by a process which is in itself not a little curious and instructive, as affording a kind of parallel to the stimulating action of Mr. Talbot's second application of nitrate of silver, in his beautiful kalotype process. The nature of the process in question, will be best illustrated by describing the experiment which led to it.

It frequently happens that papers prepared with nitrate of mercury. and the ammonio-citrates, or tartrates, with, or without, addition of tartaric, or citric, acid, fail to exhibit the peculiar properties described in Arts. 228, 229, at all satisfactorily. Indeed, to bring on the peculiar velvety effect there described, a high degree of intensity of sunshine seems to be an essential requisite, as, in a feeble sun, I have never obtained even an approach to it. A paper prepared (Oct. 28, 1842) according to the instructions of Art. 229, in every respect, except in the proportion of tartaric acid (which was somewhat less than that recommended), proved very little sensitive. A strip of this paper, half shaded, acquired after a few minutes' exposure to sunshine, only a feeble brown color over the sunned portion. Being then withdrawn,

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it was washed over with nitrate of mercury. *Immediately* the sunned portion began to darken very rapidly, while the shaded part was unaffected, and ultimately assumed a deep brown hue. Exposed while yet wet to the sunshine, this passed rapidly to intense blackness, while the portion originally shaded, which had undergone the same subsequent application, and which was now equally exposed to the sun, sustained in the short time required for bringing on this effect, no appreciable change. Indeed, it seemed rather to have become more insensible than before.

Not alone nitrate of mercury is capable of thus exciting, or stimulating, the dormant photographic impression on such paper. To my very great surprise, I found the same effect to be produced by *water* sparingly applied, so as only to moisten the paper. Across the sunned and shaded portions of a strip of the mercurialized paper, exposed till a pale brown was developed in the former portion, were drawn two streaks, one of weak nitrate of mercury, and one of spring water. Both, after a very short interval, passed to an intense brown on the sunned half, the shaded remaining unchanged. Edging the streak produced by the nitrate, was a black border, that produced by the water, was uniform, The *whole* paper was now exposed for a short time to the sun, which rapidly converted to intense blackness, both the streaks on the previously sunned half, while it produced no perceptible change in the other. I found this experiment to succeed on many different varieties of paper, and with very considerable latitude in the dosage of the ingredients. It was most successful in the case of a paper prepared with a cream, formed by mixing one measure ammonio-*tartrate* of iron (strength $\frac{1}{12}$*) and two saturated protonitrate of mercury, leaving out the free tartaric acid altogether, which, among many other doses of these two ingredients, proved also, generally, the most sensitive to light.

Led by these indications, I prepared a paper by washing, first with a weak solution of ammonio-citrate of iron (strength $\frac{1}{10}$), and when dry, with saturated protonitrate of mercury. It was exposed *when barely dry enough, not to feel damp*, with an engraving in a frame to a hazy and declining sun. In about twenty minutes, a very pale, and feeble photograph was produced. Excited, as above, by water, it gained but little in intensity (for it deserves remark, that the *increase* of apparent intensity, produced by either water, or the nitrate, is in direct *proportion* to the force of the original impression, which, as observed, was in this case very faint.) It was then held for about five minutes in the sun (near setting), and, by degrees, and with the utmost regularity of gradation over every part of the picture, each line assumed an inky blackness, the lights and shades being exquisitely preserved in their due proportions, and the ground being hardly perceptibly discolored. The result was very beautiful, and perfect negative photograph.

This singular power of water to excite the dormant impression, strongly recalls the analogous power of moisture, to deepen the tints

*By this I understand one part (by weight) salt + 11 water.

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photographically impressed on auriferous papers, of which an instance is given in Art. 45, and of which a still more striking example is shown as follows. Let a paper be washed first with ammonio-citrate of iron, and when dry with neutralized chloride of gold, and thoroughly dried in the dark. It is then, apparently, almost insensible to light; a slip of it half exposed to the sun being hardly impressed in any perceptible degree in many minutes; yet, if breathed on, the impression comes out very strong and full, deepening by degrees to an extraordinary strength. Treated in the same manner, silver also exhibits a similar property.* Nor, indeed, is there any feature in photography more general, or more remarkable, than the influence exercised by the presence of a certain degree of moisture in favoring the action of light, whether direct, or indirect.

There is this difference, however, in the excitement produced by simple water, and by the mercurial solution, viz., that the latter is permanent, the former liable to fade; at least I have found this to be the case with the brown tinge produced by it in shade, though, when blackened by a second exposure to sun, no difference is perceived. On the other hand, when the nitrate is used, the brown hue frequently passes to absolute blackness, without any subsequent exposure to sunshine; and in that case the photographs produced have an intensity, and opacity, scarcely, if at all, inferior to that of printing ink.

This high degree of opacity and depth, together with the comparative insensibility of the ground, is evidently capable of being most usefully applied to the production of retransfers. In fact, the photographs so produced, being negative, are so far fitted for the purpose, and if used as models while in this, their transition state, and as it were self-fixed, so far from being injured by the transmission of light, they are actually acquiring additional sharpness and depth, by every beam which passes. By *seizing, therefore, the right point of dryness,* and by using a very sensitive paper to receive the impression, there is no reason to doubt of success in procuring very perfect positive transfers. Some trials I have made, have satisfied me as to the practicability of this, however contrary it may at first sight appear to the usual conditions of photography. Lond. & Ed. Philo. Mag.

* Note added Dec. 21.—The excitement is produced on such paper by the ordinary moisture of the atmosphere, and goes on slowly working its effect in the dark, apparently without *other* limit than is afforded by the supply of ingredients present. In the case of silver, it ultimately produced a perfect *silvering* of all the sunned portions. Very singular and beautiful photographs, having much resemblance to Daguerreotype pictures, are thus produced; the negative character changing by keeping, and by quite insensible gradations, to positive: and the shades exhibiting a most singular *chatoyant* change of color from ruddy brown to black, when held more, or less, obliquely. No doubt, also, gold pictures, with the metallic lustre, might be obtained by the same process, though I have not tried the experiment.—J. F. W. H.

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Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.

(Continued from Page 124.)

In taking up the subject of heavy green sand moulding, we enter upon an extensive field of practice, and it will be necessary, as before, to select such examples as appear best adapted to present fair, general views of the subject.

In connexion with some observations on the practice of green sand moulding generally, stated towards the conclusion of our last article, we must, in the first place, remark the introduction of a new element, powdered coal, namely, into the sand, in a state of simple mixture; its office, as before remarked, being to assist the blackening in resisting the penetrating action of the iron. As this action exists just so long as the metal continues in a liquid state, the blackening alone proves sufficient to resist it, in cases of light moulding; whereas, in heavy mouldings, there being a much greater body of metal together, its temperature falls so much the less rapidly, and it, of course, continues its action as a liquid for a longer period. Consequently, coal powder in addition becomes necessary to withstand the attack of the iron. But, further, the proportion proper to be mixed is a matter of considerable nicety, and is dependent on two circumstances; first, the length of time that the liquidity of the metal continues, has a simple relation to bulkiness of the metal; secondly, the temperature of the metal on being poured into the mould, does proportionally increase, or diminish the original intensity of the action on the sand, as well as affect the duration of this action. The correct adjustment of this point must be left to the skill of the workman, derived from his previous experience.

A redundancy of coal in the sand renders the surface of the casting formed in it, *faint;* that is, its outlines are imperfectly developed, or, to use again the language of the moulder, the casting is not sharp. This is the natural and obvious effect of the repellent power of the superabundant gas generated by the heat from the coal. On the contrary, a deficiency of coal proves equally hurtful to the quality of the casting, as the gas produced from it is, in this case, too weak to maintain the well-balanced action of the opponent forces. The iron, having burnt through the blackening, penetrates the sand, which, at the surface, becomes incorporated with the metal, and produces, therefore, a peculiar roughness on its surface. In order to make the casting in the most proper manner, the sand and coal-powder should be mixed, not only in a proportion suited to the body of metal to be cast in the mixture, but also as uniformly as possible.

Pease-meal is not generally used in the heavier flat mouldings, its object being to hold down the blackening applied to mouldings of an intricate, or ornamental character. Now the parts of machinery generally have their surfaces plane, which are, therefore, easily accessible to the trowel and sleeker.

For large castings, the bed of sand, which forms the floor of the foundry, is commonly employed for constructing the moulds, serving

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steam engine of 20 horsepower. To begin with the sole-plate, which will be the first, and most instructive example, it is necessary to describe its construction:—

Fig. 1.

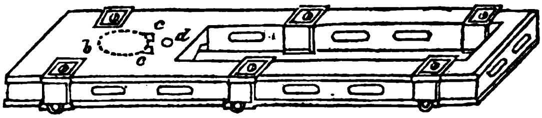

Fig. 2.

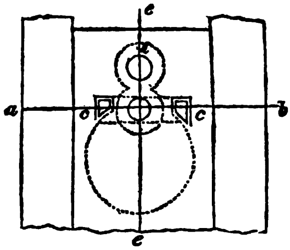

Fig. 3.

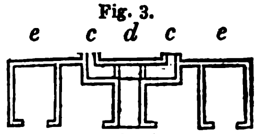

Fig. 4.

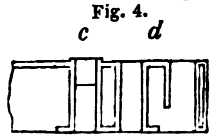

Fig. 5.

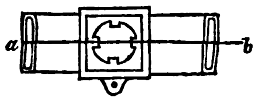

Fig. 6.

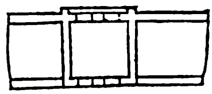

Fig. 1, is an external view of the plate, showing the upper surface. It is arranged to maintain six columns, surmounted by an entablature. At one end, *b*, a platform for supporting the cylinder is cast across the plate, stiffened by a deep flanch at the edge. The position of the cylinder is indicated by the dotted circle. When the cylinder is set in its place, the apertures, *c*, *c*, form continuations of the eduction steam passages; they are joined into one short branch-pipe below the platform. *d*, is a circular passage for the introduction of the steam into the valve chest. It is projected downwards to the level of the mouth of the eduction-pipe, both passages terminating in one large flanch, by which the respective pipes leading to them, are connected.

Fig. 2, is a plan of part of the sole-plate, including the steam-ways, showing, in dotted lines, the eduction passage, and the flanch. Fig. 3, is a vertical section of the sole, and the eduction passage at the line, *a*, *b*, fig. 2. The steam passage also is dotted in behind it. Fig. 4, is another vertical section of the same, at the line, *e*, *e*, fig. 2, showing in section both of the passages, *c*, *d*.

Fig. 5, is a plan of another portion of the sole, showing the foundation for a column; fig. 6, being a vertical section of the same at the line *a*, *b*, fig. 5. It thus appears that the sole is hollow within, and

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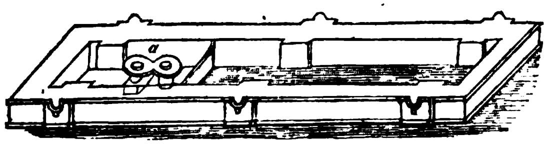
it possesses the form of section shown in fig. 3, all round, interrupted only by the sockets for the feet of the columns. It is a general practice in founding to dispose of the moulding so as that those parts of the casting towards which the greater quantity of metal exists may be undermost. In this way, greater security is found for the soundness of castings at the more important parts.

Now, the sole-plate is, for the most part, entirely open on the under side, as may be seen on referring to the section, fig. 3; it ought, therefore, to be cast with that side uppermost, according to the preceding statement.

For reasons, which will be better understood as we proceed, the pattern of the sole-plate, of the same form externally, is not made open like the sole, on the under surface. Neither are the oblong blank spaces, shown in the sides, executed in the pattern; its cross section at every point is a complete four-sided figure. This form of pattern, will, of course, leave in the sand a plain open space of the same breadth as itself. *Cores* of sand, of the form of the internal void, must, therefore, be introduced into the moulding, to complete the figure of the casting. The fig. 7, exhibits the under side of the pattern. At *a*, the pattern of the steam ways are placed. They are

Fig. 7.



not fixed to the surface on which they stand, but are simply prevented from shifting laterally by small pins, or snugs. They are made solid, so that they, too, like the plate itself, require to be cored out, and, accordingly, the prints, for securing the cores in their positions, are added to the patterns of the flanch, which itself is attached loosely to the pipe patterns. On the opposite side of the main pattern, prints are likewise fastened to receive the other extremities of the pipe cores. In like manner, prints are attached to the upper side of the pattern, to receive the cores for the column sockets, fig. 6; and to the snugs, *s*, *s*, &c., to core out the holes in them.

A level bed in the sand upon the floor, of sufficient extent, is, in the first place, prepared for the pattern, which is then set down upon it, and well bedded in its place, which is effected by blows given to it over the surface—the object being to form a complete impression of the under surface of the pattern. Sand is farther laid in, and rammed about the pattern on all sides, till it be brought up flush with the upper side, forming thereby the parting surface, on which parting sand is strewed.

The next stage of the process is to lay the upper box, or boxes, over the pattern, and to fix them in their places by stakes of wood driven into the floor, which also guide us to replace them accurately when removed. If there be not a single box large enough to embrace

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answering the purpose of a single box. The ramming of these boxes is conducted in the usual manner, except at the end, *a*.

Here, it is evident, that as the platform, or cylinder-plate, is now on the under side of the pattern, the body of sand filling the space immediately above it to the level of the upper side, must be lifted out to get the pattern removed. At the same time, the weight of such a deep body of sand adhering to that in the overlying box, would overcome their cohesion, it would break away altogether. As the box is, therefore, incapable of carrying it with it, it becomes necessary to have this load of sand supported by independent means. An iron frame is cast in open sand of the same form as the sunk space, but somewhat smaller, as allowance for the contraction of the casting, in the course of cooling, must be made to allow the plate to be withdrawn, after the casting is executed. In cases where this precaution has not been sufficiently attended to, the jamming of the plate, inclosed on more than one side, has been the natural consequence, and sometimes the destruction of the casting by consequent fracture. In the centre of the frame, a sufficient opening is allowed for the steam ways. This frame is laid in the bottom of the recess, and as its under-surface now faces the moulding, it must be enveloped on that side in the sand, to protect it from the immediate action of the metal afterwards poured into the mould. To assist its adhesion, the frame, or plate, is studded on the under side with numerous tooth-like projections, which are imbedded in the sand applied. Sand is now thrown in above the plate, surrounding the steam ways, and well rammed, its parting surface being made flush with the upper edges of the pattern of the pipe flanch in the centre, and of the contiguous body of sand, forming the interior part of the moulding, their parting being just over the stiffening flanch of the cylinder bottom. With this preparation, the upper boxes, as already said, are set down and filled.

There are prepared six pouring-gates to the moulding, and eight flow-gates. Of the pouring-gates, or those by which the moulding is filled, two are placed along each side, about four feet distant, and two at the cylinder end of the moulding, while none are made at the other end. This unequal division is necessary, on account of the heavier nature of the moulding at the cylinder end; the design of the whole being to have the moulding filled uniformly. The flow-gates are distributed equally over the moulding. These will be again referred to.

Before lifting off the upper boxes, the pattern being now completely moulded, the latter is so far loosened in the sand, that this may not stick to it, and so spoil the operation. This is effected by gentle jolts communicated to the pattern by means of one or more pieces of rod iron, which have been screwed vertically into the pattern before finally ramming the sand in the upper box, or which merely enter into holes in the pattern. These rods being sufficiently long to pass out through the sand when the box is filled, it is upon their upper extremities that the blows of the hammer are given both

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now drawn straight out, and the upper box is in readiness to be lifted smoothly off.

After the box is removed, the plate and its overlying core of sand, as it may be termed, deposited in the recess at the cylinder end of the pattern, are lifted out of their situation by arms rising through the core, carrying with them the pattern of the steam ways, which is at liberty to go; for, as we have already noticed, it stands loose on the main pattern. The pattern itself is not in one piece; the flanch, which is separate, is lifted off towards the upper side of the core, and the remainder of the pattern is drawn out by the under side. This is evidently the only mode of extracting the pattern, and shows the necessity in such cases of constructing patterns in two or more pieces to adapt them to the exigencies of the case.

The parts of the mould, in the neighborhood of the pattern, must now, after the box is removed, be pierced with small holes, executed by means of wires traversing the whole body of sand, with the view of rendering the moulding more porous, and of facilitating thereby the escape of the air and other gases. The mould is also watered along the edges, to increase the coherence of the sand.

The pattern itself is taken out by lifting it in all its parts at once, by pins secured into it at several places, so as to be raised in a truly vertical position. This manœuvre is performed by several men, who, while they lift the pattern with one hand, strike it gently, and constantly, with the other, thus continually checking any efforts made by the pattern to tear away the sand of the moulding, and now especially is this remedial application necessary, as the pattern is much more engaged in the lower moulding than in the upper, which, indeed, is the case in mouldings generally. Unavoidable degradation in one, or other, of the two parts of the mould nevertheless do occur, and these the workman repairs with damp sand by means of his trowel.

The moulding is next smoothed all over the surface by the trowel, and a sprinkling of charcoal is then applied, and polished likewise by the trowel. It is, however, omitted for very large castings. Sometimes, also, in order to avoid using too much charcoal, the surfaces are lightly dusted over with sand, finely pulverized through a bag. The moulding is now ready for the reception of the cores, the making and depositing of which claim the particular attention of the moulder, as the figure of the future casting will very much depend upon his accuracy in these respects.

Cores of several forms are necessary for the completion of the moulding. There are, first, the cores for the column sockets, of which there are six; then the cores for the intermediate portions of the sole-plate, of which also there are six, there being two on each side between the socket cores, and one at each end; again, two cores for the steam ways, with several other minor cores, for the holding-down-bolt holes in the snugs at the bases of the columns, as well as for the holes that may be required for the bolting down of pedestals, &c., to the sole. For all these, there are simple prints sprigged upon the pattern at the

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proper places, the impression of which in the sand serve to hold the cores securely.

As we have already remarked, about the beginning of our last paper, cores must be made not only of the exact size and shape of the vacancies in a casting, whether partial, or thorough, which they are intended to form; allowance must also be made on them for the core-prints, when these are necessary. This allowance then is provided in the cores of the column sockets, for which there are prints on the under side of the pattern, fig. 7. These sockets go through the sole, and are square in the body, and round at each end, as may be understood on referring to figs. 5, and 6, and to the annexed fig. 8, which is a plan of the moulding, showing the cores in their places.

Fig. 8.

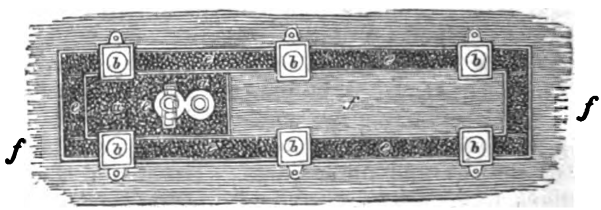

Fig. 9.

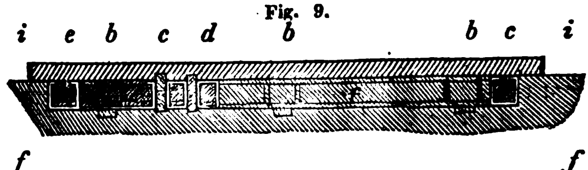

Fig. 9, is a longitudinal section of the moulding, taken through the steam ways. In both figures, *f*, *f*, *f*, is the sand of the floor, in which the moulding is formed, constituting the interior, as well as the exterior of it; *b*, *b*, &c., are the cores of the column sockets, seen in dotted lines in the section; *c*, *d*, are the cores for the steam ways, which, in fig. 9, are seen projecting in the sand, above and below, filling the recesses made for them by the prints. Figs. 2, 3, 4, explain the shape of them. They are formed in boxes, which open in two, for the purpose of extracting them. These, with all the other small cores, are dried upon hot plates, heated by stoves. At *a*, and *e*, *e*, &c., the cores are shown, forming the spaces in the moulding intended to be vacant. Near the under side of each, in fig. 9, are shown the plates, indicated by dark lines, which sustain the cores. The whole, however, must be sustained by the bottom of the moulding, leaving a space of the required thickness of the casting. This is effected by placing steeples there; these are simply strips of sheet iron of small lengths, but with double knees, thus [. If the depth of these be just the thickness of the metal, then by placing several of them along the bed of the moulding, they support the cores placed over them, keeping the space clear for the metal—of course, these steeples will be imbedded in the casting, where they are allowed to remain. The double-knee cores at both ends of the moulding, it will be observed in fig. 8, are put to-

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gether, each in three pieces. In constructing the cores, *e*, *e*, &c., plain square bodies of sand of the dimensions of the interior of the casting, are, in the first place, formed in boxes of the same size, including, at the same time, the iron frames enveloped in the cores. Now, the small cores that are necessary to the oblong openings in the sides of the casting are simply attached in their proper positions to the sides of the main cores, *e*, *e*, &c. They are formed and fixed on by simply applying upon the larger core, an open box of the form required, into which sand is packed, thus causing it to adhere to the main core; when the box is filled, the sand is squared off by a straight edge, flush with the surface of it. It is evident that if the box be lifted off, it leaves its core behind it. All the other smaller cores having been made, and set in their places, the moulding is finally closed, the upper box being replaced, as seen in section, *i*, *i*, fig. 9. This requires to be done cautiously, and in a truly vertical direction, as it now receives the upper ends of the cores which project above the moulding, and also bears upon the other cores, large and small, which do not require any additional security.

When convenient, two or more gates are connected to one central reservoir, all built on the surface of the sand. Gates at considerable distances from others, are usually supplied separately with iron from hand ladles. The other gates that are connected, are supplied from crane ladles, which are conveyed by cranes from the cupola to the moulding. The ladles will be afterwards described. The flow-gates, while the metal is being formed, are plugged with clay-balls, to "keep down the air" in the moulding. These plugs are drawn out when the moulding is filled, and the iron flows up. It is thus judged whether the casting is complete. The plugs must not be prematurely drawn, as by the too free egress given to the air, the bottom of the mould is apt to be disturbed by the air confined in the sand.

When the metal is poured, the "feeders" are immediately applied at the flow-gates. These are rods of iron, which are plunged into the liquid iron, and wrought up and down in it. By this agitative process, the liquidity of the iron about the gates is longer than otherwise maintained. It is, therefore, enabled to supply itself with additional iron from the flow-gates, for it must be understood that in the cooling down of large bodies of metal, the surface sets, while the interior is liquid; and, therefore, when the interior farther contracts, it draws in the surface metal towards the centre, and if not fed as above described, the casting assumes a vesicular structure, which weakens it considerably. To avoid such a result as far as possible, is the object of the agitation produced by the rod.

(To be continued.)

Jeffery's Marine Glue.

[A recent invention, called Marine Glue, has been produced by Mr. Jeffery, of Limehouse, which demands our attention, as from its extraordinary qualities it is likely to become hereafter of great impor-

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tance in the various purposes of ship building. We have taken the following account of it for our readers, from the inventor's description.]

Mr. Jeffery, the inventor of this substance, who was one of the early producers of copper plates by galvanic action, considered that the manufacture of copper sheathing for vessels might be improved by that process. But finding that he could not diminish the cost of production below that of plates made by the ordinary method, and that the waste by oxidation on the one hand, and on the other hand, the mischief of foul bottoms when oxidation was checked, formed insuperable barriers to success in the application of this process, he desisted from the attempt. The idea also occurred of applying gums insoluble in water, as a protection for the bottoms of ships; and by combining elastic gum with non-elastic, and charging the whole composition with ingredients destructive both to animal and vegetable life; that such a coating would protect the timbers from the contact of the water, and also prevent any adhesion, or accumulation of animal, or vegetable matter, and resist the attack of the *teredo navalis*. Mr. Jeffery accordingly made a series of experiments, and succeeded in producing a composition likely to realize all his wishes and expectations. He then deposited a sealed paper, descriptive of his discovery, in the Admiralty, with a statement as to the probable effect of the composition, and, at the same time, several blocks of wood were experimentally sunk in Portsmouth harbor, to prove that the marine glue possessed properties most useful and important for ship building, and other purposes.

Every one knows that the timbers which compose a ship, are exposed to constant strain from winds and waves, from the time the ship is launched until she is broken up. One of the qualities required in a substance used to join those timbers, must be insolubility in water, or it would be useless; it must be impervious to water, so as to prevent leakage; it must be elastic, so as to contract and expand according to the strain on the timber, or the vicissitudes of climate; it should be sufficiently solid to fill up the joint, and give strength; it should be adhesive, so as to connect the timbers firmly together. These properties Mr. Jeffery has combined, in an eminent degree, in the marine glue. One of the experiments made to test the power of this glue, was the following:

Two blocks of African oak, eighteen inches long, by nine inches wide, and four and a-half inches thick, were joined together longitudinally by the marine glue, and a bolt of one and a quarter inch in diameter, was passed through each of them from end to end, and a chain attached to it.

On the next day attempts were made to draw the blocks asunder longitudinally, by means of the hydraulic machine in Woolwich Dockyard, applied to the chain, in the presence of Sir Francis A. Collier, and the master shipwrights of the Royal Dockyards at Plymouth, Portsmouth, Sheerness, Chatham, and Woolwich. A strain, to the extent of nineteen tons, broke one of the bolts, but the junction of the wood by the glue remained perfect. Two bolts of one and a

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one tons, when one of the bolts was broken; the junction of the wood still remaining perfect, and apparently not affected.

Two blocks of African oak, of similar dimensions, were glued together, with bolts at the opposite ends, so that the strain might be applied at right angles, to the junction made with the glue. With the strain of five tons, one of the blocks split asunder at a short space from the point, but the joint remained perfect.

The result of these last experiments was deemed more extraordinary by those assembled, inasmuch as African oak is a very difficult wood to unite.

Numerous experiments have been made to ascertain the best proportions of the mixture constituting the marine glue for various sorts of wood; and in one case, where it was applied to elm, it resisted a strain equal to 368 lbs. on the square inch. This trial was made whilst the block was in a wet state, which state is considered most favorable for the effect of the glue.

Several large pieces of timber glued together, were precipitated from the top of the shears in the Dockyard at Woolwich, a height of about 70 feet above the ground, on to the granite pavement below, in order to test the effect of the concussion. The wood was shattered and split, but the glue yielded only in one case, in which the joint was badly made, and after the third fall. This falling from a height on to a hard substance, is a very severe test of the strength of a joint. The explosion of a shell has greater power in rending wood, but does not produce so great an amount of vibration.

From the elastic nature of the marine glue, it contracts when the timbers to which it is applied are swollen by water, and expands when the timbers shrink from heat, or any other cause.

A block of wood with a rend in it was taken, and the rend filled with the glue. It was then immersed for a month in a mast-pond at Chatham, at a temperature ranging between 30° and 40° Fahrenheit. On taking it out of the pond, the glue, from the pressure of the wood, was slightly squeezed out, so as to present a raised surface above the rend, but after this block had been a month in the Chatham hoop-house, at a temperature from 70° to 80° Fahrenheit, it assumed a concave figure on the surface of the rend. This block experiment is still going on, and it is intended to place the block in the hoop-house and mast-pond alternately for the space of a year, in order to ascertain whether the result will be equally successful. But in preparing the glue, its elasticity may be increased, or diminished, as circumstances may require.

This quality renders the glue most valuable as a remedy to be applied to the rends and fissures of timber; and, in fact, renders defects of that nature of little consequence—a result, of which the practical shipwright will perceive the immense importance. It is also available with peculiar advantages for the seams of vessels, in lieu of pitch; seams which were payed with it about a year since, and were exposed to the heat of last summer, appear but little changed, and are

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quite free from leakage, although they were executed under very unfavorable circumstances. For the deck seams it will be found peculiarly suited; and where it is used the crew will never have reason to complain of the glue sticking to their feet. The surface of the seams after heavy rains, or from a damp atmosphere, will become slightly convex, and under a warm temperature will become slightly concave; but it will not liquefy by solar heat, and it will, under all circumstances, adhere with its original tenacity. All practical seamen will perceive the vast importance, in point of economy, comfort, and security from leakage, which these qualities ensure, especially in hot climates.

Another important experiment has been made with the glue in reference to its being a substitute for copper sheathing. This composition was applied without poison, to four surfaces of some nearly cubical blocks of wood, and on the other two surfaces, it was applied in combination with poison, equally destructive to animal, as to vegetable, life. After the lapse of twenty-three months, these blocks were taken up, and were found to present the following appearances—small shell-fish were adhering to the four unpoisoned sides, whilst the two sides charged with the poison, were perfectly clean. The whole of the composition was slightly changed in color, but was not deteriorated, or affected, in respect of its useful qualities.

Another most important use of the marine glue, is evidently in its application to the construction of masts. Its power of adhesion, and elasticity, admirably fit it for the purpose of joining the spars of which masts are composed. A great reduction of expense is likely to follow its adoption for this purpose, as shorter and smaller timbers may be rendered available, and most, if not all, of the internal fastenings may be dispensed with.

The following account of some experiments on this point are from daily journals. The masts alluded to, have been glued with such proportions of elasticity, given to the glue, which deflect in about the same ratio as the wood itself, or as if the wood were in one solid piece.

"Experiments were carried on, January 4th, and 5th, at Chatham, in the presence of Capt. W. H. Shirreff, Superintendent, and Mr. John Finchman, master shipwright, at the Dockyard, with the marine glue, invented by Mr. Jeffery. The experiments which were carried on last year at Woolwich, with the view of improving its immense adhesive power, and that it would be more difficult to separate the joinings made with it, than it would be to tear the solid wood in pieces, by shots from the large guns of the ordnance, and the result of the trials so convinced the master shipwrights then assembled to consider improvements which might be brought forward for the benefit of the Royal Navy, that they recommended its adoption, and its application to naval purposes was approved by the Lords Commissioners of the Admiralty. The main-masts of the following vessels have been joined with it, under the instructions of Mr. Jeffery. The main-mast of the Eagle, 50-gun ship, was first fitted with it, and it now stands exposed to all the changes of our variable atmosphere; the

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substantial manner; and some idea may be formed of the number of joinings, when it is stated, the dimensions of the mast is 125 feet in length, with a diameter of 40 inches. The main-mast of the Curacoa, formerly a 32-gun ship, but at present being reduced to a 24-gun vessel, is in progress of being joined with the composition. The whole of the practical workmen speak highly of its merits, and have expressed an opinion that its general use will save a great amount of labor in placing internal fastenings, which may now be nearly dispensed with. Mr. Jeffery had an officer from Pembroke Dockyard under his instruction, who returned home with a quantity of the composition to be used in laying the decks of the Victoria and Albert steam vessel, for the especial use of her Majesty, and his Royal Highness Prince Albert.

"The experiments formerly made and tested, were undertaken at a period when a high degree of summer temperature existed, and it was imagined by some, that it would be difficult to use it in winter, so as to have equal adhesive, and strengthening powers. In order to satisfy himself on this point, the inventor had several pieces joined together during the present cold weather, and the following is the result of the trials of their qualities:

"Eight pieces of wood 12 feet long, and 6 inches in diameter at one end, and 5 inches at the other, were each cut lengthways into four pieces, and joined together with the marine glue, two of the pieces with a new sample of the composition, and the others in the usual manner, only varying the proportions of shell lac of $\frac{6}{12}$ and $\frac{9}{12}$. These pieces of wood were alternately attached by strong bolts to the floor of the mould loft; and an iron collar and chain having been placed in the centre, the following weights were placed on a balance to shew the deflection, or strain. No. 1, with the new sample, with a strain of 25 cwt., bent 3 inches exactly, and on the withdrawal of the power, returned to its former position with the greatest elasticity. No. 2, with a strain of 27 cwt., only yielded $2\frac{1}{8}$ inches. No. 3, with a strain of 27 cwt., bent $2\frac{3}{8}$ inches. No. 4, with a stain of 27 cwt., yielded $3\frac{3}{8}$ inches, having been joined by the new sample. No. 5, with a strain of 27 cwt., showed a deflection of $2\frac{1}{8}$ inches. No 6, with a strain of 27 cwt., only yielded 2 inches. No. 7, with a strain of 27 cwt., bent $1\frac{7}{8}$ inches; with $29\frac{1}{4}$ cwt., $2\frac{1}{8}$ inches; with $31\frac{1}{2}$ cwt., $2\frac{1}{4}$ inches. It was then attempted to break this model mast, and additional weights were put on, until it amounted to 45 cwt., when the strain made it yield $3\frac{1}{4}$ inches, and fractured the upper part of the wood, but did not separate the joinings, or thoroughly break the wood, and afforded those present an opportunity of satisfying themselves that the joined pieces were far stronger, in every respect, than solid wood of the same dimensions. No. 8, was tested in a similar manner, and with a strain of 45 cwt., yielded $3\frac{1}{2}$ inches, and at one end the joining opened a little in one direction, which will afford the inventor an opportunity of judging of the best degree of mixture of the various substances of which it is composed. The experiments were

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4 o'clock, P. M. on the 5th, it being only 8 degrees above freezing point. The value of the materials and invention has now been completely established, and its importance to her Majesty's Navy will be very great, as it has hitherto been found very difficult to obtain trees of sufficient length and diameter, about 22 or 23 inches, for main-top-masts for first rates; but they may now be made from any number of pieces, and from the nature of the marine glue, they will never be subject to the dry rot.

Another experiment was made by joining two pieces of wood 9 inches square, by 20 inches long, and placed in such a position that 21 cwt. of iron, forming a pile 6 feet high, about 7 inches broad, and 20 inches long, and it bore the whole weight without yielding at the time. On the second day, the wood gave way under the immense pressure, shewing the cement was more powerful and secure, than the solid timbers." We shall, in a future number, enter into further details of the value to the navy of this important discovery.

The extraordinary utility of the marine glue will not be fully appreciated, until vessels, in the construction of which it has been applied throughout, from the kelson to the main-top, shall have been exposed to disasters in which ordinary vessels would go to pieces, or founder, from leakage. In many such cases the superiority of the marine glue will hereafter be manifested, in the preservation of vessels, together with the property and lives of the persons on board.

No attempt is here made to enumerate the various constructions, such as dock gates, piers, aqueducts, floating bridges, &c. &c., to which the marine glue may be applied with advantage; the present design being simply to point out some of its principal qualities as shown by experiment.

Naut. Mag.

March 25th, 1843.

On the Principles of Aerial Navigation. By Sir GEO. CAYLEY, Bart.

Sir,—Mr. Henson having now published a description of the ærial machine, with which he proposes to make his experiments, and feeling an earnest desire that success may attend the practical development of principles which, however difficult in execution, are, undoubtedly, true in theory; I trust it will not be thought obtrusive in me to state a few leading observations with reference to the present scheme.

The magnitude of the proposed vehicle, will, I much fear, militate against its success. There appears to be a limit in nature to the convenient application of winged surfaces. We have millions of winged insects; hundreds of the smallest descriptions of birds; but the eagle, condor, and albatross, sail unmolested, as the sole tenants of the loftier regions of the atmosphere; and these, the largest of birds, probably never exceed one hundred pounds in weight. Muscular power and animal heat, appear to bear a direct ratio to the carbon consumed in a given time by the oxygen to which the blood is exposed in the

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lungs; and nature seems to have much exceeded her usual animal limits in this respect, purposely to obtain sufficient power for the flight of birds.* The weight of the body of a bird increases as the cube of its linear dimensions, so that if the length be doubled, the weight will be increased eight-fold; and if tripled, twenty-seven fold. But the surfaces of their wings only increase as the squares of their linear dimensions: hence, in this latter case, if the wings keep the same relative proportion to the increased length of the body, as they did in the original size, they would be too small in the ratio of the square of three to the cube of three, or as 9 to 27, being only one-third part of the proper size to give due support to the weight.

Hence, also, if the original proportions are the most convenient, and appropriate, for the degree of leverage against which the muscular power can act—the most suitable for compactness of structure, and for the covering and warmth of the body—then these conveniences must be sacrificed to the necessity of giving three times greater surface to enable the bird to fly; and, in the structure of the albatross, it is said there is an additional joint, to increase its extent of wing. It is difficult, perhaps impossible, for man to trace all the secrets of nature, as to the limiting causes affecting the dimensions of the different species of the animal creation; though we seem, in the present age, to be getting a glimpse of such matters. The particular degree of gravitation towards the earth we inhabit—the exact force of chemical combination between the various particles of matter, and of general galvanic power over each and all, modified, perhaps, by the mechanical properties of leverage and position—probably form the elements taken into consideration by that Divine mind which called all these powers into existence, to fulfil the benevolent purposes of His will. But it is time to return from this digression, to the particular case in point.

Mr. Henson proposes the machine to have a lateral extension of 150 feet, by 30 in width; thus forming a surface of 4,500 square feet. The extent of leverage, however well guarded by diagonal braces, is in this necessarily light structure, terrific. For, although the wings are not intended to be wafted, the atmosphere, even in moderately calm weather, near the earth is subject to eddies; and the weight of the engine and cargo, &c., in the central part of this vast extent of surface, would, in the case of any sudden check, operate with enormous power to break the slender fabric. In the largest birds, the leverage of the extreme points of their wings seldom exceeds 6 feet; whereas, the extent of wing on each side of Mr. Henson's machine, is 75 feet; therefore, every pound in the central part of this fabric, operates with more than eleven times greater effect of leverage, than every pound of weight forming the body of the largest bird.

This consideration shows that in order to obtain a sufficient quan-

* The power of consuming the carbon in the blood, for the supply of muscular activity, and animal heat, is best estimated by a comparative view of the number of times one can breathe in a given time. The horse breathes 16 time a minute; a man 18 times; whereas, a common fowl breathes 30, and a pigeon 34 times a minute, according to Prevost and Dumas, as quoted by Professor Liebig.

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not to be made in one plane, but in parallel planes, one above the other, at a convenient distance, so as to form a more compact fabric, with less extent of leverage. The progressive velocity will prevent these planes from interfering with each other, in giving their due support. If, therefore, so large a surface be contemplated for trying this experiment, would it not be more likely to answer the purpose to compact it into the form of a *three decker*, each deck being 8 or 10 feet from the other, to give free room for the passage of the air between them?

This vast surface is all extended in one nearly horizontal plane, which is not the form experimentally proved to give the proper lateral stability to the machine. It was remarked in my last letter, that the surface should be made in the form of the letter V, though of a much more obtuse angle. Extensive principles are often shown by very insignificant means; and every school-boy knows that his shuttlecock, whichever way it may be struck into the air, is never off its balance. Several winged seeds are likewise, on this principle, borne steadily on the air. As very little of the support is lost by this mode of constructing surfaces for ærial navigation, when not carried to excess,—whereas, the security of the conveyance is very greatly increased by it,—it ought not to be neglected in an experiment, quite sufficiently fraught with danger, after every precaution shall have been taken.

Aerial navigation by mechanical means alone, must depend upon surfaces moving with considerable velocity through the air; but these vehicles will ever be inconvenient, not to say absolutely inefficient, if to effect this they must have an elevated point to descend from; for, to be of ordinary use, they must be capable of landing at any place where there is space to receive them, and of ascending again from that point. They should likewise be capable of remaining stationary, or nearly so, in the air, when required.

Very great power, in proportion to the weight of the engine, is necessary to answer these, or, indeed, any of the purposes of ærial navigation by mechanical means alone. It is, in fact, the ***sine qua non*** of the case; and Mr. Henson will deserve great credit if he be able, by any invention of his own, or combination of the inventions of others, permanently to maintain the power of twenty horses, by an engine not exceeding 600 lbs. in weight. If that gentleman do not deceive himself in this estimate of the power he proposes to use, well directed experiments will soon point out the proper mode of its application.

There can be no doubt that the inclined plane, with a horizontal propelling apparatus, is the true principle of ærial navigation by mechanical means, as it is that of the flight of birds; and although it has been fully investigated, and there is nothing new in it, the principle, has, as yet, remained dormant, for want of sufficient power. This principle Mr. Henson adopts, and the requisite power he proposes to supply.

It is not correctly known at what angle with the line of flight the wings of birds are applied; indeed, this probably varies with the

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comparative size of the wing to the weight of the bird; hence no very accurate estimate of the power exerted can yet be made; but, from sundry experiments with inclined planes, it seems probable that for every thousand pounds weight of the ærial vehicle, eight or ten horses' power will be required.

The larger the surface in proportion to the weight, the less velocity it requires for its support; and as Mr. Henson's machine is said to have a surface in proportion to its weight, exceeding that of most birds, its velocity will not be so great as that of birds. Should he, therefore, fully succeed in his project, the velocity of his flight may be taken at something short of that of the crow, which, in calm air, is 24 miles per hour, and is about the ordinary railroad speed. The direct resistance of the car, masts, and rigging, in the construction of ærial vehicles, will, should they ever succeed, probably put a limit to their velocity, not much exceeding 24 to 30 miles per hour.

It has long since been proved, so far as engineering calculations, founded on tolerably well ascertained data, may be trusted, that elongated balloons, made on a very large scale, and of firm, air-tight materials, may be driven through calm air, by engine power, at a velocity approaching the railroad pace, and, by their buoyancy, carry, whether stationary, or in motion, a considerable cargo. Hence, on a great scale, balloon floatage offers the most ready, efficient, and safe means of ærial navigation.

"The enormous bulk of balloons, as compared with the weight they will sustain, causes the *difficulty* of impelling them, with sufficient speed to be of any utility, either by manual, or engine, power; and this *difficulty*, is, by many truly scientific persons, considered as insurmountable, because they conceive that the bulk, which causes the resistance, must ever be commensurate with the weight of engine necessary to propel them by any species of waftage—and, consequently, as it will not do on a small scale, that it cannot on a large one. It is true, that it requires twice as much gas to sustain a 4 horse power engine, as to sustain one of a 2 horse power (with their loads of fuel and water); but it is not true that the larger balloon, though perfectly similar in make to the smaller one, will, when driven through the air at the same velocity, meet with *double* the resistance—if it were so, the case of steering balloons would be hopeless, and on this mistaken ground many think it a vain attempt. This idea, resting at the very threshold of the invention, and which seems to present an insurmountable barrier, when probed and fully investigated, proves to be false, and the investigation leads to an immutable law of proportion between the resistance, and the capacity to carry weight, or engine power, which, on a very large scale, promises the most satisfactory result.

"If balloons of the respective diameters of one and two, both being spherical, be driven through the air with equal speed, the resistance will be as the *surfaces* opposed to the air, and the surface of the largest will be four times greater than that of the smaller, and hence it will require *four* times the engine force to keep up the velocity;

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greater than that in the smaller; hence it could sustain eight times as much engine power; but four times that power would keep up the required velocity, and hence it could carry a cargo of the weight of its engine, and yet keep pace with the smaller balloon. The simple terms of the case are, that the surfaces (and hence the resistances) increase as the *squares* of the diameter of the balloon; whereas, the capacity to contain gas (and hence the supporting power) increases as the *cubes* of the diameter.

"From this *unquestionable* law it follows, that if similar shaped balloons vary in diameter as the numerals, 1, 2, 3, 4, 5, &c., the resistance they will meet with in the air, at the same velocity, when compared to the weight (or engine power) they will sustain, will be as 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c. This is a most important fact, and proves that as the law of relative diminution to resistance is *unlimited*, there must ever be, *theoretically*, some bulk in which any species of first mover, however sluggish in proportion to its weight, would find itself suspended, and its power adequate to propel that bulk with the velocity required."*

Elongated balloons of large dimensions, thus offer greater facilities for transporting men and goods through the air, than mechanical means alone, inasmuch as the whole weight is suspended in the air without effort; and when the invention is realized, it will abundantly supply the increasing locomotive wants of mankind, for which, in due time, it was probably designed. Mechanical flight seems more adapted for use on a much smaller scale, and for less remote distances; serving, perhaps, the same purpose that a boat does to a ship, each being essential to the other.

One great difficulty to be overcome in mechanical flight, is the enormous difference of the powers required to perform it, as birds do, by any direct downwards waft in the first instance, as compared with the skimming action on the principle of the inclined plane. The surface of a square foot, if loaded, as it is in the crow, with a pound weight, would descend perpendicularly with a velocity of 21 feet per second; hence, to sustain his weight, he must press his wings down with that velocity, which is equivalent to lifting his own weight 21 feet per second. Now, if an ærial machine were to weigh 1000 lbs., and it had to be lifted with this velocity, the force required would be that of 38 horses; and Mr. Henson's engine, if loaded in the same ratio, would be a 114 horses' power. The bird even exerts a still greater effort, for he has, in the downward beat, to make good the time lost in the ascent of his wing.

The crow, in skimming, goes about 36 feet per second; during which time, if unaided by any waft to propel him, his descent will be about one-eighth of 36, or $4\frac{1}{2}$ feet. The power required, therefore, cannot be greater than in the ratio of $4\frac{1}{2}$ to 21; and in this case 1000 would, in the skimming action, require a $8\frac{1}{4}$ horses' power, to main-

* From Practical Remarks on Aerial Navigation, by the author of the present article, in *Mech. Mag.*, for March 4, 1837.

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tain it, provided it were performed as in birds, by the surface being moved downwards, when obliquely raised at the hinder portion, so as to continue during this action, the same force of the air applied under the surface, as when the front portion of it is elevated, and the bird skims for a time by its previously acquired momentum. It is not yet ascertained what the actual angle of the bird's wing is, and the absolute power required for propelling ærial vehicles, cannot, therefore, be stated with certainty, though we thus make some tolerable approximation to the truth.

Fig. 1.

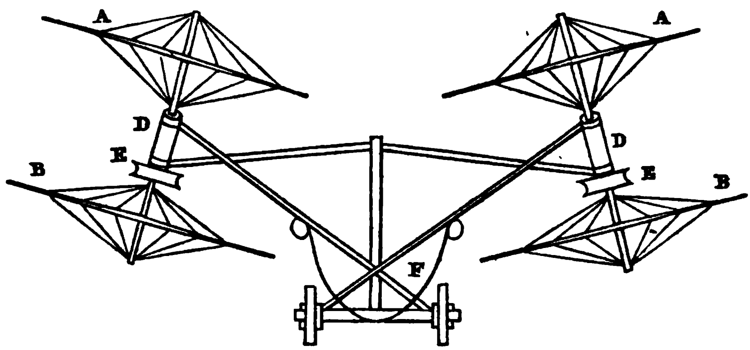
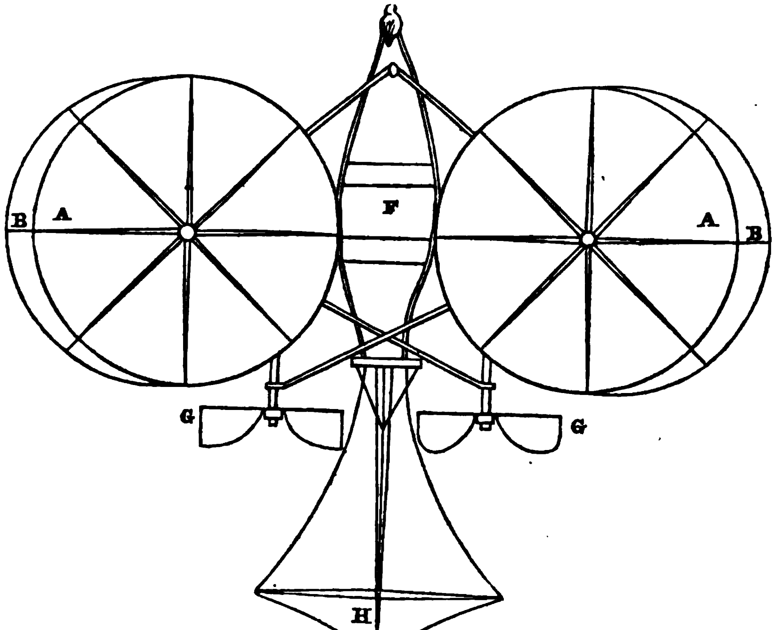


Fig. 2.



The capacity of varying the degree of power to so great an extent in muscular action, gives much greater facility to the flight of birds

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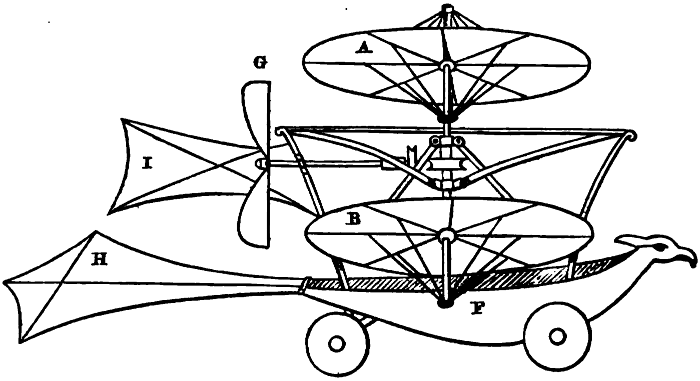
Under this general view of the case, I have endeavored to combine all the requisite principles of action that have been enumerated. Fig. 1, 2, and 3, will exhibit, without tedious explanation, the construction of an ærial vehicle, containing about 530 square feet of surface. Fig. 1, shows an end view in elevation; fig. 2, a bird's-eye plan; and fig. 3, a side elevation.

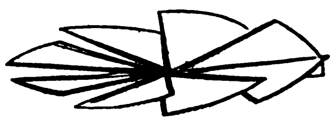
Fig. 3.



The main surfaces, A, A, and B, B, are here placed one above the other, and each pair are connected together by strong shafts, firmly fixed into sockets at each end of a steel axis, which turn freely in their collars, D, D. These shafts carry a spiked pulley, or drum, E, E, by which they may be turned by a pierced belt, or chain, from the engine in the car, F.

The construction of these circular planes is such, that when only required as a stationary expanse of surface, they continue in one even, or rather slightly curved, state, like a very flat umbrella; but when the engine power is applied, to make them revolve in their proper directions, one set adverse to the other, they are immediately, by that act, thrown open, into the form of the flier, fig. 4, and thus the surface, to a great extent, is made to skim, though the machine may be stationary—the upper edge of each section in these fliers being foremost.

Fig. 4.



It must also be observed, that the two sets of fliers are placed in the obtuse V form, to ensure lateral steadiness to the machine. These may be termed the elevating fliers, to distinguish them from two other smaller ones, G, G, set at a very different angle with their axis, and used for propelling the machine, when the others are stationary; both sets will be put into action gradually, or in any required degree, by friction plates, as is usual in such cases.

If the elevating fliers have a diameter of about 11¼ feet each, they will contain about 100 square feet of surface; yet by this construction, the leverage of the centre of their support, on each side, will

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only be about 8 feet from the centre of the car, and this will be firmly sustained by the diagonal bracing of the framework.

The framing is also adapted to increase the stationary surface, by being covered with canvas in the obtuse V form down to the edge of the car, and overhead, like a very flat roof, to keep off rain, &c. This surface, as here shown, would be about 130 feet, but, by the addition of a couple of light yards, as in the sails of ships, it might be much increased, with little additional weight.

The broad horizontal rudder, or tail, H, capable of being turned on its hinge to any angle, at pleasure, gives the power of ascent, and descent, when the propellers are used, and forms also the chief means of stability in the path of the flight.

The small vertical rudder, I, is for the purpose of lateral steerage in combination with the two propellers, which, by being used singly will turn the machine with great power; and if one be reversed by the same means as those now used for steam paddles, a still greater lateral guidance can be obtained.

This construction of an experimental machine for mechanical aerial navigation, is not offered in the light of a finished model; but more to show, in combination, certain principles which must be attended to in their construction, to give them a fair chance of success. It will give me much pleasure, if anything experience may have taught me on this subject, can be turned to any account in the present project, which Mr. Henson has now made his own by patent right. I am, however, of opinion, that balloon navigation is that designed for the uses of mankind, on the large scale; but as this letter has already far exceeded its due limits, I must refer such of your readers as may choose again to examine the capabilities of balloon floatage, to an article in No. 708 of your Magazine for 1837. I think it a national disgrace, in these enlightened locomotive times, not to realize, by public subscription, the proper scientific experiments, necessarily too expensive for any private purse, which would secure to this country the glory of being the first to establish the dry navigation of the universal ocean of the terrestrial atmosphere.

April 2, 1843. Lond. Mech. Mag.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Boilers. By Thos. W. Bakewell.

I have just received the July number of the Journal, and hope this short piece may be in time for that of next month.

I should have no objection to make to the analysis of E., could his premises be admitted "mais voila l'embaras," he assumes the parallelism in action of the steam peculiar to the received theory, which, in this instance, is vertical. Referring to the diagram of E., in the July number,* let the half section, A, B, D, terminate at A, and B, by being at those points attached to a solid body, occupying the space below A, B. Now, this change will not, in the least, effect the deductions of E.; for, on the received theory, the tendencies to rupture at D, the leverage = D, A, and the turning point at A, remain un-

* Page 54.

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the solution of the parting force at D, would still hold, by a slight variation in the definition of terms.

With the half section attached, as above, to the solid body, the operative force to rupture at D, would, on both theories, be as the semi-diameter; and, at B, by the received theory, as the semi-radius: whereas, I contend, that the solid body below A, B, has not effected any change in the conditions of the point, B, which would receive a strain to part horizontally, equal to the quarter circle.

Should, what I have stated, or may state, on this subject, be thought of sufficient importance to induce a trial by experiment, a semi-circle of a flexible material, as here represented, attached to a solid body, would be the simplest method, and form the strongest contrast in testing the two theories; for, at B, the difference would be as 1 to 3.14; or, by the received rule, the semi-circle would uniformly part at A, or B, and by mine, at B.

Cincinnati, 30*th July*, 1843.

ERRATA.

Page 102—20th line, for "*greater*," read "*quarter*."
" " 26th " "*greater*," " "*quarter*."
" " " " "*directions in one*," read "*directions; to be resisted in one*."
" 104—20th " "*pursuaded*," read "*persuaded*."

Experiments on the explosive force of Oxygen and Hydrogen gases.

By James Johnston, Esq.

In 1841 I took out a patent for obtaining motive power from the explosive, and condensing properties of oxygen, and hydrogen gases. In order to ascertain the power and length of stroke which those gases would give when exploded in a cylinder, I commenced, on the 24th of April, 1841, a set of experiments, of which I now give the results.

The apparatus with which I made the experiments, consisted of a strong cast-iron cylinder, accurately bored, so that its diameter was exactly two inches and thirteen-sixteenths of an inch. This diameter gives a surface on the piston of six square inches.

The piston was fitted very accurately into the cylinder. I have ascertained it to work perfectly air-tight. On the top of the piston, there is a cross-head, and spindle, for placing weights upon. The ends of the cross-head work in cast-iron guides.

The gases are admitted to the cylinder by stop-cocks, and are exploded by an electric spark.

I shall now describe the preliminary arrangements made before making each experiment.

I ascertained the weight of the piston, piston-rod, and other appendages, which the gases must move when the piston is put in motion, to be 9 lbs. 5 oz.

I then ascertained, that, to overcome the friction of the piston, it required 5 lbs. 1 oz., together with its own weight; therefore, add 5

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lbs. 1 oz. to 9 lbs. 5 oz., and we have 14 lbs. 6 oz., the weight, or force required to overcome the friction of the piston.

I now proceeded to load, as follows, the piston, so that I would give the gases 5 lbs. per square inch of weight to lift.

Weight of piston,	9 lbs.	5 oz.
Amount of friction of piston,	14 "	6 "
Amount of weight required to make up the 5 lbs. pr. sq. in.,	6 "	5 "
To weight.	30 lbs.	0 oz.

This gives 5 lbs. per square inch of weight, as there are six square inches of surface on the piston.

I measured the gases in the cylinder by the height to which I raised the piston. Every inch of distance between the bottom of the cylinder, and the bottom of the piston, holds six cubic inches. When making the experiments, I always raised the piston to the height which I wished it to be at, by placing under the ends of the arms of the cross-head pieces of wood made for the purpose. After the piston was thus raised to its required height, the apparatus was ready for the explosion, as the gases were admitted at the pressure of the atmosphere at the time the piston was raised.

The gases were kept ready for use in a bladder mixed in the proportions of two parts of hydrogen, to one of oxygen.

Having described the arrangements for insuring accurate experiments, I now give the results in the following table, of which the first column gives the quantity of gas in cubic inches, which was placed in the cylinder at each experiment.

The second gives the weight that was placed on the piston in pounds per square inch of its surface.

The third gives the height in inches, and tenths of inches to which the explosion drove the piston.

The fourth gives the height of the barometer at the moment each experiment was made.

The fifth gives the height of the thermometer at the same time.

Gas.	Weig't.	Height.		Bar.	Ther.	Gas	Weig't.	Height.		Bar.	Ther.
		In.	Ten.					In.	Ten.		
6	5	1	8	29.4½	53½	21	20	2	7	29.5¾	54½
9	5	2	9½	29.4½	53½	6	25	0	3	29.5¾	54½
12	5	4	4½	29.4½	54	9	25	0	4½	29.5½	54
6	10	1	0	29.4¾	54	12	25	0	8	29.5¾	54
9	10	1	8	29.4¾	54	15	25	1	1¼	29.5¾	54
12	10	2	5½	29.4¾	54	18	25	1	4½	29.5¾	54
15	10	3	6½	29.4¾	54	21	25	1	7½	29.5¾	54
6	15	0	7	29.5	54½	24	25	2	2	29.5¾	54
9	15	0	9¾	29.5	55	6	30	0	1½	29.7¼	57
12	15	1	6	29.5	55	24	30	1	1	29.7½	57
15	15	2	1½	29.5	55	24	45	0	3¼	29.8½	52
18	15	2	8½	29.5	55	24	50	0	1¾	29.1	43
6	20	0	3¾	29.5¼	54½	24	55	0	1	29.1	44
9	20	0	7¼	29.5¼	54½	24	60	0	0¾	29.0	45
12	20	1	1¼	29.5¼	54½	24	65	0	$0\frac{1}{20}$	29.0	45
15	20	1	5¾	29.5¼	54½	24	70	0	$0\frac{1}{40}$	29.0	45
18	20	2	2	29.5¾	54½	24	75		0	29.0	45

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inch, the explosion was unable to lift the piston; it merely shook the weights.

The above table gives the maximum results of upwards of two hundred trials, or experiments, which I have made on the explosive force of the mixed gases.

In order to show that there is an unaccountable irregularity in the results of my experiments on the gases, I shall now give a few experiments which were made with the same gases, and under the same circumstances.

Gas.	Weig't.	Height.	Bar.	Ther.	Gas.	Weig't.	Height.	Bar.	Ther.
		In. Ten					In. Ten.		
6	5	1 4¾	29.4½	53½	6	5	1 5½	29.4½	53½
6	5	1 5	29.4½	53½	6	5	1 7½	29.4½	53½
6	5	1 3½	29.4½	53½	6	5	1 8	29.4½	53½
6	5	1 3	29.4½	53½	6	5	1 5	29.4½	53½

In the above eight experiments between the maximum and minimum rise of the piston, there is a difference of five-tenths of an inch. How this difference arises I am at a loss to know. A difference of about the same extent existed throughout all my repetitions of experiments. I have bestowed a great deal of labor, and attention, to find out how this difference arises, and I am satisfied that it has not its origin from any defect in my apparatus, or arrangements. I believe it arises from the difference of strength that may exist between the different sparks of electricity with which the gases were exploded, as it was with the spark from a Leyden jar with which I exploded the gases. I intend making a set of experiments, in order to ascertain this point.

When commencing those experiments, I attempted to explode the gases by the spark which is formed when contact is broken between the wires of a battery; but I found that this spark, although very bright, would not explode the gases. The battery which I used for this purpose, was composed of eight narrow cast-iron troughs, with a plate of zinc in each, measuring twelve inches square.

Willow Park, Greenock, 15*th March,* 1843. Edin. New Phil. Journ.

English Patents.

Specification of a Patent granted to Thomas Banks, of Manchester, in the county of Lancaster, Engineer, *for certain improvements in the construction of Wheels and Tires of Wheels, to be employed on Railways. Sealed* 13*th June,* 1842.

These improvements in the construction of wheels, to be employed upon railways, consist, firstly, in a peculiar method of constructing the nave, or boss, of such wheels, for the purpose of securely fastening the wrought iron arms, or spokes, in the nave, and preventing their becoming loose.

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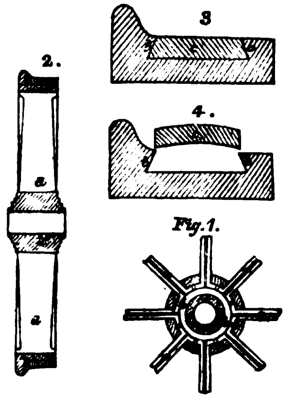
wheel, constructed according to this improvement. The wrought iron arms, or spokes, are shown at *a*, *a*, which may be formed according to any of the well known plans already in use. These spokes, or arms, are then to be welded, riveted, or otherwise securely attached, to a wrought iron ring, *b*, *b*, and then the boss, or nave, *c*, *c*, is formed by casting, or running, melted metal entirely around the ring, *b*, so as to embrace and inclose the inner ends of the spokes, *a*, *a*, and the ring, *b*, *b*, as shown in the figure.



2. 3 4. Fig. 1.

By securing the wrought iron arms to a ring of wrought iron, previously to casting the metal around the ends of such arms to form the nave, or boss, an increased security will be given to the arms in the nave, or boss, and greater strength and durability will be obtained.

The second part of the improvement consists in placing, or inserting a hoop, bar, or segments of steel, iron, or hard metal, in a groove, turned, or otherwise formed, entirely around the outer rim, or periphery of a railway wheel, such groove being properly shaped to receive the steel, or other hard metal. Fig. 2, represents a section, taken transversely through a railway wheel. *d*, *d*, *d*, represent the rim, or periphery, arms, and nave. The improvement consists in forming a groove, *b*, *b*, either dove-tailed, (as shown in the figure, or otherwise,) shaped entirely around the outer rim, or periphery, whatever the material of the wheel; and in placing, or inserting, therein a hoop, bar, or segments of steel, iron, or hard metal, either in one entire piece around the circumference of the wheel, or in smaller pieces, or segments, placed together, end to end, so as to fill the groove formed round the periphery of the wheel. Fig. 3, represents, in section, a portion of the felly, or rim, and tire of a railway wheel; and fig. 4, is a similar section, excepting that in the latter, the steel bar, hoop, or segment, *c*, is represented as about to be placed in the groove, *b*, *b*; which groove is shown as it is cut or formed in the felly, or rim, previously to the steel being inserted. The bar, hoop, or segments of steel, or other hard metal, being heated, are introduced into the groove, and spread laterally, so as to fill, or become tight in the groove, by hammering, or other pressure, as represented in fig. 3.

Steel, or other hard metal, as above described, may be applied to the working surface of the flanch of the tire. A separate groove may be made in the flanch, or the groove shown in the drawing may be extended further towards the flanched side of the wheel, so as to steel that part of the flanch on which the friction, against the edge of the rails, principally takes place. In applying this improvement to the tires of wheels, whether new or old, made according to the usual method, it will be necessary to form the groove to the requi-

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site size and shape; or, if a groove be left, when the tire is formed, it may be enlarged, according to the wishes of the manufacturer, to receive the steel; and the above mentioned hoop, bar, or segments of hard metal, may be easily removed when worn, and renewed from time to time, as long as the general fabric of the wheel is sufficiently firm for use.

The patentee, in conclusion, states that he is aware of steel having been used, before the date of his letters patent, for the tires of wheels, to be employed on common roads and railways, by other persons, and under letters patent, granted to Daniel Gooch, bearing date on, or about, the 28th day of May, 1840, for the use of steel in wheels for carriages, and locomotive engines, to be used on railways, by forging, or welding, together bars of iron and steel; that he does not, therefore, claim the use of steel generally on tires for railway wheels, or the use of steel on such tires, when the iron and steel are welded together in the formation of the tire-bar; but he does claim the improvement in the tires of wheels, to be employed on railways, by inserting a hoop, bar, or segments of steel, or other hard metal, in a groove, turned, or formed, entirely round the rim, or tire, of such wheels as above described.—[Enrolled December, 1842.]

Lond. Journ. Arts & Scien.

Specification of a patent granted to JOHN MULLINS, of Battersea, Surrey, *for certain improvements in making oxides of metals, in separating silver, and other metals, from their compounds with other metals, and in making white lead, sugar of lead, and other salts of lead, and salts of other metals. Patent dated October* 27, 1842; *Specification enrolled April* 27, 1843.

Mr. Mullin's improvements are six in number.

First, he produces oxides of lead and other metals by forcing currents of atmospheric air, or oxygen gas, through masses of the metal in a melted state, "heated to the temperature of their respective points of oxidation," and then skimming off the oxides from the surface.

Second, to make white lead, he exposes the oxide of lead obtained by the preceding process, which is stated to be much superior to the ordinary litharge, and vitrified massicot of commerce, to the vapors of vinegar, and carbonic acid gas. Or,

Third, he exposes a solution of acetate of lead, or other suitable salt of lead, made from "the oxide obtained as aforesaid," to an atmosphere of carbonic acid gas. We quote at length the patentee's description of the mode in which this is effected; it is new, ingenious, and, we think, likely to answer well.

"In chambers, or large jars, of earthenware, or other material, are suspended several large sponges, which are supported in the jars by strings of worsted, so as not to touch the sides of the jar, or one another. Having made a saturated, filtered, and neutral solution of acetate of lead, or of other suitable salt of lead, from the oxide ob-

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tion, and also the worsted strings suspending them, the strings are then made to dip into the solution contained in the vessel above the jars, and, by the power of capillary attraction, the sponges are kept constantly moist by a supply of the solution descending down the worsted strings; and the supply can be regulated at pleasure by the size of the strings, or otherwise. Evaporation is continually going on, and crops of salts of lead are formed on the surface of the sponges. The jars are made to communicate with a gas-holder, or other reservoir, containing carbonic acid gas, which gas is made to fill the jars, in order that the sponges may be surrounded with an atmosphere of carbonic acid gas. By the action of the gas, the salt of lead on the sponges is readily converted into ceruse, assisted, probably, by the decomposition of the acid of the original solution. When it has been ascertained that a sufficient quantity of the ceruse has been formed, the sponges are removed, and washed in a vessel of pure water; and if the sponges contain any undecomposed soluble salt of lead, which is generally the case, the water dissolves it; but the ceruse falls to the bottom, on the water remaining at rest. The water is to be re-used for forming the solution when decanted from the precipitated ceruse. The sponges are then replaced as before, and the process continues."

Fourth, he employs common soot to deoxidize his oxide of lead, and generally for the reduction of all metals from their ores, or oxide.

Fifth, when a mass of melted lead, treated by the process just described, contains any silver, the silver, being less oxidizable than the lead, accumulates at the bottom of the pot, whence it is drawn off occasionally to be farther purified and separated.

And *sixth*, to separate iron, the oxides are discharged down a shoot, fixed at an angle of about 30°, formed of wood, or some other non-conducting material, from the bottom of which the poles of a number of magnets project upwards, and to which a slow, lateral, sieve-like motion is given by machinery; the magnets attract and retain the iron, and the oxides pass free.

Lond. Mechanics' Mag.

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METEOROLOGICAL OBSERVATIONS FOR MAY 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barometr. Sun Rise.	Barometr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	48°	62°	29.30	29.72	W.	Moderate		Clear.	Flying clouds.
	2	38	59	30.06	30.14	W.	do		Clear.	Clear.
	3	46	54	30.20	30.24	SE. NE.	do		Cloudy.	Cloudy.
	4	40	64	30.24	30.24	NE. S.	do		Clear.	Clear.
	5	47	65	30.20	30.20	SW. E.	do		Par. cloudy.	Clear.
	6	44	67	30.20	30.20	SE. S.	do		Cloudy.	Par. cloudy.
☾	7	56	68	30.00	29.86	SW.	Brisk	.67	Par. Cloudy.	Shower.
	8	60	70	29.80	29.80	W.	do		Cloudy.	Flying clouds.
	9	52	70	29.88	29.95	NW.	Moderate		Par. Cloudy.	Par. cloudy.
	10	50	49	30.06	30.06	NE.	do	.38	Cloudy.	Rain.
	11	46	56	29.96	29.95	NE.	do		Cloudy.	Cloudy.
	12	48	76	29.90	29.90	E.	do		Clear.	Clear.
⊗	13	52	80	29.83	29.83	W. SW.	do		Par. Cloudy.	Par. cloudy.
	14	54	80	29.80	29.83	SW.	do		Clear.	Clear.
	15	60	82	29.80	29.80	SW.	do		Clear.	Light clouds.
	16	60	79	29.70	29.80	W.	Brisk		Clear.	Clear.
	17	58	61	29.85	29.96	W.	Moderate		Clear.	Cloudy
	18	47	64	30.10	30.10	NE.	do		Cloudy.	Cloudy.
	19	49	71	30.10	30.00	E.	do	.01	Par. cloudy.	Rain.
☽	20	50	70	29.85	29.80	E.	do		Cloudy.	Par. cloudy.
	21	46	75	29.66	29.60	SE. W.	do		Hazy.	Hazy.
	22	52	75	29.60	29.60	W.	Brisk	.06	Hazy.	Rain.
	23	55	74	29.65	29.65	W.	do	.12	Par. cloudy.	Rain.
	24	52	71	29.70	29.70	W.	do		Clear.	Clear.
	25	49	70	29.75	29.75	W.	do		Clear.	Clear.
	26	52	74	29.80	29.90	E SE.	Moderate		Lightly cloudy.	Light cloudy.
	27	54	68	29.78	29.78	N.	do	.06	Rain.	Cloudy.
	28	53	65	29.86	29.86	SW.	do		Cloudy.	Cloudy.
☺	29	48	54	29.65	29.65	SE.	do	.74	Rain.	Rain.
	30	48	71	29.65	29.65	W.	do		Clear.	Clear.
	31	56	60	29.55	29.61	W.	do		Cloudy.	Cloudy.
		51.29	67.87	29.85	29.82			2.04		

Thermometer. Maximum 82 on 15th. Minimum 38 on 2d. } Mean, 59.58

Barometer. Max. 30.24 on 3d. & 4th. Min. 29.30 on 1st. } Mean 29.835

JUNE, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barometr. Sun Rise.	Barometr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	42°	57°	29.75	29.85	W.	Moderate		Lightly cloudy.	Lightly cloudy.
	2	38	64	30.05	30.05	W.	do		Clear.	Clear.
	3	57	77	29.80	29.75	SW.	Brisk	.25	Cloudy.	Rain.
	4	62	75	29.75	29.75	W.	Moderate		Cloudy.	Par. cloudy.
☾	5	67	86	29.65	29.66	W.	Brisk	.30	Cloudy.	Par. do.—rain.
	6	64	73	29.63	29.70	W.	do		Cloudy.	Clear.
	7	54	72	30.00	30.05	W.	do	.1	Clear.	Clear—rain.
	8	59	75	30.10	30.06	S.	Moderate		Lightly cloudy.	Clear.
	9	64	86	29.85	29.80	W.	Brisk		Par. cloudy.	Clear.
	10	70	87	29.70	29.64	W.	do	.18	Cloudy.	Rain.
	11	75	70	29.60	29.65	SW. W.	do		Cloudy.	Par. cloudy.
⊗	12	55	76	30.02	30.05	W.	do		Par. cloudy.	Cloudy.
	13	56	75	29.85	29.76	SW.	Moderate		Cloudy.	Clear.
	14	67	84	29.60	29.65	W.	Brisk		Clear.	Clear.
	15	56	78	29.70	29.70	W.	Moderate	.12	Rain.	Par. cloudy.
	16	64	82	29.76	29.70	W.	Brisk	.06	Cloudy.	Rain.
	17	60	74	29.85	29.86	NE.	Moderate		Clear.	Clear.
	18	52	72	29.95	30.00	W.	do		Clear.	Clear.
☽	19	56	76	30.06	30.00	SW.	do		Clear.	Clear.
	20	52	78	30.20	30.24	W.	do		Clear.	Clear.
	21	64	82	30.14	30.14	W.	do		Clear.	Clear.
	22	68	81	30.00	29.95	W.	do		Rain.	Par cloudy.
	23	66	85	29.90	29.85	W.	Brisk		Clear.	Clear.
	24	70	88	29.70	29.70	W.	do	.1	Clear.	Clear—shower.
	25	68	82	29.70	29.80	W.	Moderate		Par. cloudy.	Clear.
	26	64	87	29.86	29.87	W.	do		Par. cloudy.	Par. cloudy.
☺	27	70	88	29.86	29.88	W.	do		Clear.	Par. cloudy.
	28	75	81	29.84	29.79	SW.	do		Cloudy.	Cloudy.
	29	71	85	29.75	29.75	W.	do		Clear.	Par. cloudy.
	30	70	87	29.78	29.70	N.	do		Clear.	Clear.
		61.53	78.77	29.85	29.85			.93		

Thermometer. Max. 88. on 24th. & 27th. Min. 38. on 2d. } Mean, 70.15

Barometer. Max. 30.24 on 20th. Min. 29.60 on 11th & 14th. } Mean 29.85

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JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

OCTOBER, 1843.

Franklin Institute.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on the best modes of Paving Highways.

The Committee on Science and the Arts, constituted by the Franklin Institute, of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the following portion of a joint resolution of the Select and Common Councils of the City of Philadelphia, passed January 5th, 1843, to wit: "Resolved, That the Franklin Institute, be requested to communicate to Councils, any information they may think proper, in relation to the best modes of paving highways," REPORT thereon as follows:

(Continued from Page 168.)

2. *Of Pebble Pavements.*—Pavements of rounded water worn pebbles, or small boulder stone, have been, and still are, so extensively used in almost every country, that they must be familiar to all who have ever examined the subject in hand, and will, consequently, require but a brief description.

The *pebble pavements* employed in the city and districts of Philadelphia, are generally constructed as follows:

The natural soil is first excavated to a depth of about 20 or 24 inches below the top of the curbstone, so as to receive a bed of gravel at least 12 inches deep; this gravel is not compacted otherwise than by the occasional passage of the carts hauling it, and the pebbles to the place; the pebbles are set by hand upon the gravel bed, and well rammed three times over, gravel is then spread, and kept upon the surface for some time after the street is opened for travel, in order that all the interstices between the pebbles may become firmly filled.

The pebbles employed, are generally elliptical in their vertical sections, and usually run from five to ten inches in depth, the largest and

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while the rest are reserved, and used, for the middle of the carriage way.

The curbstones used within the city proper, are divided into two classes of the following dimensions:

1st. class,	24 inches deep;	5 ins. thick;	and 4 ft.	minimum length.
2nd. "	15 "	4 "	" 3 "	"

The first class, when set, costs about 45 cents, and the second class 30 cents per foot lineal; these curbstones are usually of gneiss rock, and are not dressed as well as they ought to be; indeed, many of them are scarcely dressed at all, but are set in the street, nearly as they come from the quarry.

The curbstones used in the districts adjacent to the city, are of somewhat smaller dimensions, and cost nearly the same per lineal foot, when set.

Curbstones are usually set to show from six to eight inches vertically, clear of the brick gutters, though, in some extreme cases, where a great flow of water takes place, they have been made to show a foot without augmenting their depth; but wherever they project so much, they are disturbed by the frost in such manner, as to require resetting annually—in fact, to possess a proper degree of stability, a curbstone ought not to show above the gutter, more than one-third of its depth.

The streets paved with pebbles have a rounded surface formed in the transverse section, by means of a flat curve, the crown of which rises generally from six to nine inches above the gutter levels.

The gutters formed upon each side of the carriage way, to drain off the surface water to the sewers, are generally laid transversely with bricks on edge, and are, consequently, about nine inches in width.

The footways are commonly paved with bricks laid flat, "*herring-bone fashion*," and ascend, from the curbstones to the buildings, at the rate of a half inch rise, to one foot base.

The cost of the pebble pavements in Philadelphia, has been determined by long experience, and may be divided into two classes.

Firstly, where a new street is paved, inclusive of the brick gutters, and of all materials and workmanship, the aggregate expense is from ninety cents, to one dollar, per square yard of surface, measuring the whole horizontal space between the curbstones.

Secondly, where an old street is repaved, in which case, small quantities of new materials are required, and the expense varies from 40 to 50 cents per superficial yard of the whole surface between the curbs.

We learn from the last report of the city commissioners—for which, and other important information, we are indebted to Adam Traquair, their president—that during the year 1842, there were made, under the orders of the city commissioners, 5,590 square yards of *new paving*, at an aggregate expense of $ 5,269.83, *or*, 94 *cents per superficial yard.*

From the same source we have ascertained, that during the same

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of *repaving*, at a total outlay of $6,363.47, *or 48 cents per superficial yard.*

In the district of Moyamensing, *the new pebble pavements* have cost from 90 to 95 cents per square yard; and in some of the other districts, the same quality of work has been done for private individuals, *at* 90 *cents per superficial yard.*

At present it is probable, that 90 cents per square yard for *new paving*, and 45 cents per square yard for *repaving*, are, respectively, fair prices for the pebble pavements, as they now are executed; and even if they were done in a superior manner, one dollar for the former, and a half dollar for the latter, would still be a sufficient remuneration.

The curbstones and footways, under the laws now in force, are paid for by the private individuals whose lots they front, and are not chargeable upon the public treasury.

Such is a brief account of the cost and execution of the pebble pavements of Philadelphia; and we conceive that this kind of paving may be improved in quality, without the necessity of incurring much additional expense.

Thus we think that the gravel foundation ought not to be less than 16 inches deep, though this increased depth of 4 inches, will, at the average price of gravel, add about 5 cents per square yard to the cost of the pavement.

The gravel, instead of being loosely thrown in, ought to be well compacted, by rolling it in *three layers* with a heavy roller, and the top should be finished off with a depth of loose gravel merely sufficient to receive the pebbles.

The pebbles themselves ought to be of good form, and should be sized, so as not to be less than 6, nor more than 8 inches in depth, and all rude, unshapely masses ought to be rejected entirely.

It is not easy to prescribe exact dimensions for stones so irregular as pebbles from their nature are; but in selecting them, none should be received, which, when properly set, would be of greater diameter horizontally, than vertically.

Probably the best shape for these paving stones, would be (to speak in mathematical language) *that of a prolate spheroid, generated by an ellipse, of which the major axis is double the length of the minor one,* such a stone when set in a pavement, would present flat curved ends, and if 8 inches deep, would be 4 inches thick at the middle.

This description of stone ought to be kept in view, and approximated to, in purchasing and selecting suitable pebbles for a pavement; though, as a matter of course, it is not absolutely necessary to be very precise in affairs of this nature, and the inspection will probably be sufficiently rigid, if, from a mass of pebbles of general good shape, we reject all that have greater breadth in their proper position, than they have depth; or, in other words, if we reject all that are flatter than spheres.

The pebbles being carefully selected, and set by hand in the 16 inch foundation of gravel, should be well rammed *thrice over*, and,

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finally, the whole surface should be covered over 3 inches deep with gravel, which should be allowed to remain under the travel for one month; and whenever from frequent sweeping, or other causes, the gravel works out from between the pebbles, and allows them to project boldly up, the street should then immediately be regravelled, as above, or it will soon break up in consequence of the stone having lost their lateral support.

With regard to *repaving* an old street, we will here remark, that an injudicious practice prevails in this city upon such occasions, of loosening up, and hauling off, a part of the gravel foundation of the old pavement which had become firmly consolidated by use, and supplying its place, at some expense, with loose material, by no means equal, as a foundation, to that which is usually dug up and carried away; this practice, certainly, ought to be terminated, as being not only useless, but positively injurious.

We find that the same practice prevailing in London, as well as here, induced a person named Hobson, in 1827, to take out a patent in England, with the view of obviating its evils, and as some of the remarks in Hobson's specification appear to be judicious, if not novel, we will quote a portion of it, as follows:

"Instead of picking up the ground loose, (as is the practice in the present mode of repaving) ram the ground, on which the paving is to be placed, well down until it is as solid as possible, to a form corresponding with the form the surface of the paving is to take when finished."

"The stones employed should be sorted, so as to be nearly of an equal depth."

A pebble pavement constructed as we have above indicated, *would cost, for new paving, about a dollar, and for repaving, about a half-dollar, per superficial yard;* measuring, as usual, the whole horizontal space between the curbstones, and including the brick gutters in the above prices.

The value of a firm foundation for a pebble pavement, is well exemplified in a statement made to us, by Messrs. Price and Fox, the surveyors of the district of Spring Garden, which was to the following effect:

"That in forming the pebble pavement upon the Ridge Road, where the old turnpike was, the surface of that turnpike road was as little disturbed as possible, and where it was least disturbed, and the least gravel was used, that part has stood admirably, better, indeed, than any other pavement in the district; and no part of the old turnpike road being much below the bottom of the pebble pavement, it has all stood well."

The comparative superiority, in point of durability, of the pebble pavement laid upon the rudely paved surface of the old Ridge turnpike, as described before us, by the surveyors of Spring Garden, is certainly a strong corroborative argument in favor of stable foundations for all pavements, and confirms the propriety of the preference given by us, in a previous part of this report, to a sub-pavement of pebbles, as a foundation for a pavement of dressed stone.

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of carriages traveling along them; they are spaced from middle to middle, at the usual distance apart of the wheels of common road vehicles, and like the railways of the same name, (which they resemble, omitting the upright flanch) they are designed to carry, indiscriminately, the carriages in use upon the usual highways of the country.

These *tramways*, or trackways, as they are also sometimes called, are usually formed of two parallel lines, or rails, of long stone, from 18 to 24 inches broad, and about a foot thick, upon which the wheels of passing carriages move, whilst the horse-path, or space between them, as well as the rest of the roadway, is usually paved with pebbles.

The leading example of this mode of paving highways, is to be found in the streets of Milan, where the tramways are of stone, a yard in breadth, and where the beauty and excellence of the carriage ways have long formed a theme of admiration for travelers in upper Italy.

Tramways of cast iron plates, 2 inches thick, and 8 inches wide, laid upon stone supports, flush with the surface of the road, have been used with complete success, in the streets of Glasgow, to reduce the traction upon a hill which rises at the rate of 1 in 20; and on this grade they enabled horses to draw up 4 tons with apparent ease; but it must be admitted, however, that notwithstanding their utility, cast iron tramways are objectionable on account of their expense.

John MacNeill, a distinguished English civil engineer, several years ago, stated, in an article on Tramways, that, ... "Trackways of granite have been lately laid on the turnpike road between Coventry and Nuneaton, and are found to answer exceedingly well. In this case, as the horses work two abreast, they are obliged to travel on the stone tracks as they work in the lines of the wheels; in the others already mentioned, the carts, or wagons, are drawn only by one horse in the shafts, by which means he travels on the pavements between the lines, and not on the tracks themselves. This, however, produces no inconvenience whatever, and no obstruction to the horses, from slipping, or any other cause."

Sir Henry Parnell remarks, in relation to this subject, that "the plan of paving which contributes most to diminish the labor of moving heavy weights on roads, is that of forming as hard and smooth a surface as can be formed, with stone for the wheels of carriages to roll upon. This is effected by making use of large blocks of granite, or other hard stone. Roads of this kind, when the blocks are about 16 inches wide, and are laid in parallel lines, are commonly called stone tramways, or trackways."

"On a well constructed road, or trackway, of this kind, it has been proved by experiment, that a London draught horse can draw on the level, *ten tons*."

Stone tramways were used by Sir Thomas Telford, upon the great Holyhead road, with the most decided advantage, to diminish traction upon hills, where the configuration of the country compelled him to adopt inclinations of 1 in 20.

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In such cases nearly the same advantage in reducing the draught of carriages, results from the use of tramways, as would be obtained by cutting down the hills one half, and making the surface of the road of broken stone alone.

The commercial road from the West India Docks to Whitechapel, London, which was constructed under the direction of James Walker, C. E., in 1829, is a well known example of the advantageous character of stone tramways.

It is made "with large blocks of granite, five or six feet in length, sixteen inches wide, and twelve inches deep, laid for the wheels to run upon, as on a tramroad of iron, except that there is no flanch. The space between the granite blocks is paved."

The foundations of stone tramways have usually been made either of a rough pavement, dressed off with broken stone of small size, as in Telford's mode of forming highways, or else the tramway blocks have been laid down upon a bed of broken stone alone.

Either of these plans will, doubtless, answer the purpose, but we have reason to believe, that a well rolled gravel foundation, *will generally be sufficiently solid,* if the blocks of the tramways are made two feet in width, so as to distribute the pressure over an extended surface.

Nevertheless, in streets where a very heavy travel is anticipated, it may, perhaps, be found advisable, in preparing the foundations for the blocks composing the tramway, to form under the centre of each line, a pebble pavement, say three feet wide, then to cover this with about two inches depth of gravel, well, and firmly rolled, and, finally, upon this well compacted surface of gravel, to lay down the tramway.

The stone blocks, to form a good tramway, ought to be dressed with their top surfaces parallel to their beds, their ends wrought square, so as to fit close, and their sides scabbled off, so as to be vertical, and nearly parallel when set: *the blocks to be about two feet wide, one foot thick, and from four to six feet in length.*

The upper surfaces of the tramway should be flush with the general outline of the carriage way, and the pavement of pebbles between the lines of stone blocks, ought not to have any more curvature than is due to the general transverse profile of the street.

Stone tramways, such as have been above referred to, will, undoubtedly, form a very superior highway; they strongly recommend themselves for use in the American cities, on account of their comparative cheapness, and, excepting for the leading thoroughfares, where a smooth and uniform surface over the whole width of the carriage way, is demanded by a crowded travel, stone tramways would certainly afford all the necessary facilities for transportation, whilst their economy, the ease of traction over them, the smoothness of the motion, and reduction of the noise of passing vehicles, would be found very advantageous.

We may now conclude this branch of the subject, by inviting attention to the great advantages possessed by tramways, in their superior applicability to all inclinations, however high may be the gradient

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secure foothold for the horses which draw the passing vehicles, the carriage wheels rolling upon the smooth parallel lines of stone blocks, experience less resistance than they meet with upon any other form of stone pavement, and this advantageous property renders tramways superior for some situations, even to pavements of dressed stone, since the latter become too slippery under foot, when applied to streets having a strong grade; and hence, would be inapplicable to the inclinations descending to the Delaware front of Philadelphia, whilst, for such slopes, stone tramways would be particularly suitable.

Section V.

Pavements Suitable to Philadelphia.

In forming an opinion of the kinds of pavement which seem to be the best suited to the circumstances of Philadelphia, the relative cost of the several plans, has, in every case, been closely considered, and that consideration has led us to recommend the adoption of the following system of paving, not, perhaps, as being the best possible, but as the best attainable by a moderate outlay; and, we have, moreover, in our estimates of cost, *sought rather to err in excess, than in deficiency.*

As has been done before by others, it will be sufficient for us to divide the streets into three classes, dependent upon the extent and character of the travel carried by each.

Streets of the first class, or the leading thoroughfares of the city, possessing, by our hypothesis, a very heavy and crowded travel, will eventually require a smooth, and durable surface for the whole breadth of the carriage way, *and, consequently, ought ultimately to be uniformly paved with blocks of dressed stone, disposed in the diagonal manner, upon a sub-pavement of pebbles;* this species of pavement, if executed in the substantial manner recommended by us, *will cost about three dollars per superficial yard.*

This price is certainly a large one, when compared with the cost of the same extent of other kinds of pavements, and hence, we presume, that it will be found necessary to employ pavements of dressed stone in Philadelphia, with a very sparing hand, in consequence of the great expense attending them, though, for streets filled with a crowded travel, there would seem to be no other pavement equally suitable.

The cost of the rude specimen of stone block pavement now laid in this city in Chesnut street, between Fourth and Fifth, was about $ 2.50 per square yard of surface, exclusive of the gutter stone, which were a separate charge; and the president of the city commissioners informs us, that the stone blocks delivered upon the sidewalks for the pavement in Chesnut, between Fifth and Sixth streets, cost $ 2 per square yard of the surface they will lay; and that the total expense of that pavement, will not, probably, exceed $ 2.50 per square yard, or the same as that of the pavement east of Fifth street.

In forming pavements of dressed stone for carriage ways, it is necessary to confine their application to those streets which have gentle

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for advantageous use by horses.

It is probable that the inclination in Chesnut street, descending eastward from Fourth street, which has a grade of $2\frac{9}{10}$ feet rise, to 100 feet base, or 1 in 34, is as steep as any upon which the use of dressed stone pavements would be advisable; and it would not seem to be expedient to employ them upon any of the hills descending to the Delaware front of the city, since, excepting Spruce street, where the descent is gentle, they have gradients varying from *seven* to *nine* feet rise, for an hundred feet base, or inclinations from 1 in 14, up to the strong grade of 1 in 11.

For streets of the second class, or those of medium travel, which include the majority of the public highways of Philadelphia, *we recommend the employment of stone tramways, combined with pebble pavements,* such as have been briefly described in the fourth section of this report.

A pavement of this nature, though of quite an imperfect character in point of materials and workmanship, was laid in the year 1837, in Arch street, between Twelfth and Thirteenth, which is still in tolerable order, though it has received but trivial repairs since being put in use, notwithstanding that the stone blocks composing the tramways, were too soft, of unequal texture, and had scarcely received any dressing to cause them to fit each other, or to bring their surfaces into line.

We regard this experiment, in view of all the circumstances attending it, as being signally successful, and this fact, when superadded to the favorable considerations we have previously mentioned, and to the successful use of stone tramways elsewhere, appears to us to offer the strongest inducements for extending the use of pavements of this nature here.

The stone tramway blocks employed in Arch street, cost 37½ cents per lineal foot of each line, or if we suppose two tramways, or four lines of blocks, to be laid in a street of 26 feet carriage way, they would, at that rate, clear of the intervening pebble pavement, cost about *fifty cents* per square yard of the whole surface between the curbstones, or, in other words, they would exceed the cost of an ordinary pebble pavement, as follows, if we include with the tramways, the intervening pavements of pebbles with which they are combined, to wit:

Taking for example 9 ft. lineal of pebble pavement with a 26 ft. carriage way, we should have 26 sq. yds. at 50c., $13.00

Now, taking 9 ft. lineal of pebble pavement, and stone tramways combined, we should have 36 lin. ft. of blocks at 37½c., $13.50

26 sq. yds. of pebble pavement less $2 \times 4 \times 9 = 8$ sq. yds. occupied by the tramway blocks, if 2 ft. in width, or $26 - 8 = 18$ sq. yds. peb. pav. at 50c., - - 9.00

Or 26 sq. yds., at 86½c., - - - - - - $22.50

Difference, $ 9.50

Or $\frac{\$9.50}{26} = 36\frac{1}{2}$c. per square yard.

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Hence, from the above calculation, it appears that if a 26 feet carriage way were laid with two stone tramways, and pebble pavements combined, then, at the prices assumed above, such a pavement would cost 86¼ cents per square yard of the whole surface, or 36¼ cts. more than the general average cost of *repaving* a street in a proper manner with pebbles alone.

Since the tramways in Arch street, however, were formed of stone of smaller dimensions, and inferior quality, to those which we recommend for use, the material of the latter would cost more.

Nevertheless, since, in repaving streets, we do not contemplate the removal of the existing consolidated gravel foundations—a source hitherto of considerable unnecessary expense—since, contracting for large amounts of stone tramway blocks at once, would reduce the price per foot lineal, and, since the tramway stones themselves would occupy about one-third of the surface of the carriage way, in a street of the common width of 50 feet from house to house; we entertain the opinion, that to repave a street, already paved with pebbles, in a proper manner, and insert suitable stone tramways, two in number, or four lines of stone blocks, *would not cost more than one dollar per square yard of the whole surface between the curbstones, if the usual brick gutters are used.*

Such a price for a good repaving, and introducing stone tramways into our streets, would seem to be within the compass of moderate means; and hence, we are the more strongly induced to request the particular attention of the city authorities to pavements of this species, and earnestly to recommend their gradual adoption for the great majority of the highways of Philadelphia, or streets of the second class, as we have designated them.

For streets of the third class, being those which carry the least travel, and include the minor streets, with all the lanes, and alleys, we recommend in general, a continuance of the present mode of paving with water worn pebbles, employing, however, the improvements which have been suggested; and employing, too, in some of the various alleys which carry much travel, a species of tramway formed of smaller blocks than in the main streets; since a precaution of this kind appears to be necessary in some of them, as the cart-wheels traveling always on the same track, are found to destroy the pebble pavements very rapidly.

Such pebble pavements when composed of stone of proper shape and quality, averaging about 6 inches in depth, and set in a sufficient bed of gravel, appear to form the cheapest, and most suitable surfaces for streets, lanes, and alleys, where the travel is not great, and if they be executed as we have proposed, *the cost of new paving streets in a proper manner, with good pebbles, will not exceed one dollar per square yard, whilst the average cost of repaving, will, probably, fall short of a half dollar for the same extent of surface,* since, as we have before intimated, we would not, in repaving a street with pebbles, attempt to pick up, and remove the existing well consolidated gravel foundations, where yet of sufficient depth, but would simply

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add as much new gravel as might be found necessary to restore the street pavement, when finished, to its proper height and profile.

This course would be both less expensive, and less laborious, whilst it would make a better pavement than the method usually pursued at this time in repaving our streets.

In each and all of the above plans, the gutters and curbstones may be formed as is at present customary, though it would be a great improvement, if stone gutters, and cut granite curbing joggled together, were more generally introduced into our leading streets.

In addition to what we have said in reference to *pebble pavements*, we would recommend that the pebbles employed, *should be, as far as practicable, sorted into sizes*, so that the depths of the pavements formed with them, may be as uniform as possible; and so that no necessity shall exist of intermixing large and small stones in the same pavement at random, which tends to produce inequality of surface, and is, doubtless, a source of instability.

In a pavement of dressed stone, the diagonal system might be brought into play, by a "*herring-bone*" disposition of the stone blocks, as in the brick footways, if it were not for the necessity which would thence arise, of hewing all the stones like bricks, to exact dimensions; a mode of proceeding, which would, to some extent, enhance the cost of the pavement, without apparently producing a commensurate benefit.

Section VI.

Plans and Specifications of the Pavements recommended.

In the event of the paving and repaving of Philadelphia being annually let out *by contract*, at such prices as may be fixed by the public competition of responsible men—the propriety of which we shall discuss in the next section of this report—it will be proper in all cases to accompany the contract by a detailed specification of the work to be done, which will form, in fact, a part of the article of agreement between the parties, and which ought to be illustrated, when necessary, by drawings upon a large scale publicly exhibited, and explained to all applicants at the time of giving out the contracts.

This plan of proceeding is that which, for many years, has been customary in letting out the work to be done on the public improvements of the country, and has been shown by ample experience to be both explicit and satisfactory.

We, therefore, propose in this section, briefly to indicate some of the leading points which ought to be embodied in drawing up specifications to govern the construction of the three kinds of pavement which have been recommended by us for adoption; leaving the details, however, to be filled in by those who may have charge of the work, on the part of the city.

A Specification for a Pavement of Dressed Stone, should provide;

1. That the stone themselves be of uniform quality for any one street, and of hard, tough, and durable rock, well rammed when set.
2. That the stone blocks be rectangular parallelopipeds, nearly

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joint shall show an opening of more than one quarter of an inch, whilst, in general, they shall be but three-sixteenths.

3. That the depths of all the blocks shall be, uniformly, *exactly eight inches;* that the breadths may vary from 7 to 9 inches, and the lengths from 8 to 10 inches, provided, however, in case of any variation from the standard breadth of 8 inches, sufficient stone of each breadth shall be furnished to form a complete diagonal course with its triangular closers, and that the separate breadths employed, shall be all determined by iron gauges, applied by those who dress them, and marked with paint upon the showing surface of each stone, as fast as they are dressed off, so as to facilitate the laying down of the pavement.

4. That in point of materials and workmanship, the prepared stone when delivered, shall be fully equal to duplicate specimens dressed to the requisite fineness of joint, and submitted by every contractor along with his proposal.

5. That the transverse outline of the finished pavement shall be formed by causing the stone blocks to rise at once from the gutters one and a half inches, the projecting angle thus formed being either *rounded, or chamfered off,* as soon as the pavement is set; that the surface then shall form a flat curve, having an average ascent of one-fourth of an inch to the foot, from the sides to the middle of the streets, so that in a carriage way 26 feet wide, inclusive of gutters, the crown of a pavement of the proper transverse profile, would have an elevation of 4½ inches above the gutter level.

6. That the foundation shall consist of a pebble pavement, formed upon a well rolled gravel bed, of 12 inches average depth; that this sub-pavement shall extend from curb to curb, be, upon its surface, parallel to the profile fixed for the street, and be dressed off to receive the stone blocks with two inches depth of gravel, well compacted under heavy rollers, and accurately brought up parallel to the proper profile of the finished pavement.

7. That the stone blocks shall be disposed diagonally in the pavement, in courses forming angles of 45° with the axis of the street, and running forward towards the right hand; that these courses shall be terminated next the gutter stone, by triangular closers accurately dressed to fit.

8. That the gutters, and curbstones, shall be formed by long blocks of stone in the usual manner, the former being furnished, and laid, by the contractor for the pavement of dressed stone.

9. That the pavement, when finished, shall be covered over with gravel three inches deep, which shall remain on for one month after the street is opened to the public travel, in order to insure the complete filling of all the joints, and save the new pavement from concussion, until it has had time to consolidate.

10. That throughout its whole progress, all the work connected with the pavement, shall be subject to the inspection, and approval, of some officer of the city; and that the finished pavement shall not

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be received from the contractor, until that officer shall certify that it has been executed in strict conformity to the specification, and contract, and to his entire satisfaction.

11. That the finished pavement shall be measured by an officer of the city; and that the contractor shall be paid the stipulated price for each *superficial yard* of the whole horizontal surface between the curbstones, inclusive of the intersections of the streets, contained within the lines of the curb produced, where they are paved by the same party.

A Specification for a Pavement of Pebbles, should provide;

1. That the stone shall be of good spheroidal shape; that they shall be river pebbles, and that they shall have an average depth of 6 inches when set.

2. That the average depth of the gravel foundation shall be 16 inches, or 13 inches deep next the gutters, and 19 inches at the crown, the base line being level from side to side.

3. That the transverse profile of the finished pavement, shall be a flat curve, having, on both sides, an average rise from the gutters to the middle, of about half an inch to the foot, so as to bring the crown of a carriage way 26 feet wide, up to an elevation of 6 inches above the gutter level.

4. That the main body of the gravel foundation shall be formed in at least two layers, well consolidated separately by rolling, and dressed off with only the quantity of loose gravel which may be actually necessary to set the pebbles properly.

5. That in setting the pebbles they shall be placed in absolute contact with each other, and that they shall be thoroughly rammed thrice over.

6. That the best shaped pebbles, shall be selected, and set to form the middle of the carriage way, while the ruder ones should be employed in paving the sides of the streets, next to the gutters.

7. That the gutters are to be formed of bricks set on edge, in the manner now usual in the city.

8, 9, and 10. Same as the 9th, 10th, and 11th points of the specification for pavements of dressed stone.

A Specification for Stone Tramways, combined with Pebble Pavements, should provide;

1. That the transverse profile of the street, the quality of the pebbles used, and the general mode of forming the pavement, should be the same as is provided for in the specifications for pebble pavements.

2. That the second layer of the gravel foundation should be brought up by rolling, precisely parallel to the intended outline of the street, and to the proper height for receiving the tramway blocks, beneath which, in particular, it should be thoroughly consolidated. The tramway blocks should then be set upon this well rolled surface, and the remainder of the pavement should be finished off flush with their surfaces, with water worn pebbles, in the usual manner.

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3. That the tramway blocks should be composed of a hard, tough, and durable rock, dressed with the top and bottom beds parallel, having their ends squared off, so as to set a joint of three-sixteenths of an inch, whilst their sides should be roughly scabbled, so as to be nearly square with the beds. The dimensions of these blocks to be 2 feet wide, 1 foot thick, and from 4 to 6 feet in length, each.

4. That the four lines of stone blocks forming two tramways in a street, should be spaced equally at 5 feet apart from middle to middle, and should be set with their top surfaces flush with the prescribed outline of the street.

5, 6, and 7. Same as the 9th, 10th, and 11th points of the specification for pavements of dressed stone.

Such, in brief, are the principal points which ought to be embodied in framing specifications for the three species of pavements referred to; but there are a number of minor particulars, which, with the above, should be set out with the minute particularity usual in drawing the specifications of works of engineering, of which, in point of fact, the formation of highways is but a branch.

In the event of putting under contract the pavements of Philadelphia, proposals from responsible men should be invited through the press, for, at least, one month previously; and plans, and sections, of the several pavements, drawn upon a large scale by the city surveyor, should be prepared, and publicly exhibited. Whilst, at the same time, printed copies of the specifications, designed to control the execution of the work, should be furnished to all applicants, and explained, if necessary, by the proper officer, so that they may be clearly understood by those who propose to act under them.

With these precautions in explaining, and illustrating, beforehand, the work to be done, combined with a judicious selection of the men to do it, there will be no difficulty in finding good contractors to construct the pavements here, in a manner much superior to that at present practiced, whilst their expense, at the same time, would, undoubtedly, be diminished.

Section VII.

Superintendence and Mode of Executing the Work.

Experience upon the public works of the country has completely shown, that by far the most expensive mode in which States, or Corporations, can execute works, requiring manual labor, is to employ hands to do them by the day.

On the other hand, experience upon the same works, has also demonstrated, on a large scale, that the cheapest mode of doing work is by contract.

An objection is commonly made to contracts, upon the ground that in consequence of its being the direct interest of the contractor to slight his work, it is difficult to get it done in a sufficiently good manner.

This objection is, however, only partially valid, since the country is full of examples of excellent work done by contract. And, in fact, to procure good work from contractors, if the specifications are ex-

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plicit, and the superintending officer competent to the duties of his station, but two things are necessary, to wit:

1. *That the prices of the work should be fair.*
2. *That the supervision should be stern.*

To secure the first, it will be necessary to open the work to public competition from responsible men, and to let the work at its value only to those, who are in every sense, competent to execute it.

To secure the second, it is merely requisite that the superintending officer should be honest, competent, and firm.

Though it may be true that some of the worst work in the country has been done by contract, it is equally true that some of the very best quality has also been executed in the same manner, so that no sound argument against the contract system, can be based upon the fact, that bad work has been done under it, since, that such has occasionally been the case, is almost wholly owing, either to a culpable laxity of supervision, or to indirect influence having been brought to bear upon the officer in charge of the work.

Several of the members of this committee, from their professional service upon the public works, have it in their power to state cases which fell under their own observation, where work done by the day for corporations, even under apparently good supervision, has cost far more than similar work executed for the same corporation, or in the same section of country, *by individual contract.*

This course, however, does not seem to us necessary, and might not be agreeable to persons connected with the works referred to; we shall, therefore, omit the citation of particular examples, and, backed by the experience of the country in analogous affairs, we will confine ourselves to expressing the decided opinion, *that all the paving and repaving of Philadelphia, ought to be annually let out by contract, to the lowest competent and responsible bidder, in an open competition, by proposals previously invited by ample public notice.*

To let out the formation of the public highways by contract, carries with it the necessity of placing the execution of the work under a rigid, and intelligent superintendence; and as the construction, and repair of highways is but a branch of the profession of the civil engineer, it seems to us that the most appropriate superintendent for the public highways, would be *the city surveyor*, who, from the nature of his office, should necessarily be acquainted with the elements of engineering, and, therefore, be much more competent to direct the progress of affairs of this nature, than the worthy citizen to whom they are now confided, who, being selected from the people without any particular regard to their knowledge of these subjects, cannot, in general, be expected to possess the requisite information.

In recommending, then, upon the score of economy, that the work upon the highways of Philadelphia, should be done by contract, *we also recommend that those contracts should be rigidly executed under the orders of the city surveyor, and his assistants.*

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We are here induced to remark, that the great cost of pavements of dressed stone, on the one hand, and the comparative cheapness of stone tramways, upon the other, induce us to request the particular attention of the authorities of this city, to pavements of the latter description, as being, probably, the most suitable for the largest portion of the public highways.

Stone tramways possessing such advantages, in point of reducing the draught of the horses employed upon them, and being particularly applicable to hills, such as those descending to the Delaware front of the city, we would suggest the propriety of laying down tramways at an early period, in some, if not all, of the east and west streets, from Front street to the river.

In connexion with the subject in hand, we would recommend the gradual introduction, throughout the leading streets of the city, *of stone, instead of brick gutters*, the latter requiring frequent repairs, and exposing an immense number of joints to allow the filtration of water to injure the foundations of the pavement, as well as to admit of the injurious action of frost.

Gutter stone ought to be hewn from a hard, and durable rock, in lengths of from 4 to 6 feet; they should be about 12 inches wide, by 6 or 8 inches deep, or thick, and should be so dressed, that, when set, the joints shall be close, and the surface regular.

The curbstones commonly employed here, appear to have sufficient dimensions as prescribed by ordinance of councils, except, perhaps, in thickness, to which, a small addition would be desirable.

In setting curbstones, it would be a great improvement, if their joints were more closely dressed, and if an iron dowel were inserted vertically in each joint, and run with sulphur and sand, to prevent one stone from being pushed outwards, independently of another.

It is moreover to be hoped, that since the curbstones are at the expense of those private individuals whose lots they front, our citizens will more generally employ curbstones of well dressed granite, tongued and grooved together, like those fine specimens recently placed, by our enterprising townsman, Dr. Swaim, in front of his property, at the corner of Seventh and Chesnut streets, which, besides their promised durability, are certainly an ornament to the pavement.

The brick footways, also, admit of being essentially improved, by paying more attention to their foundations; thus, if, instead of employing a little loose sand for that purpose, *six inches* in depth, of good gravel, well rammed, in, at least, two successive layers, were used to receive the bricks, a decided improvement in the evenness, and stability of the sidewalks would be the result; or if, still better, the bricks were laid with good strong mortar, upon a bed of concrete from *four to six inches thick*, resting on a well rammed bed of gravel, dressed off to the proper slope; in that case our "*herring-bone*" brick

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pavements* would leave nothing to be desired in point of durability, and smoothness of surface, especially if concealed gutters should come into use, instead of the open ones now employed.

As an evidence of the great durability which may fairly be expected to result from the employment of brick footways *upon solid foundations,* we refer to the well known promenade along the fore-bay, in front of the wheel-house, at Fairmount; this is paved flatwise, with the usual quality of bricks, laid directly, with a little gravel, upon the solid foundation furnished by the masonry of the head arches; and though this pavement has been exposed to a very considerable foot travel ever since it was placed there, in the year 1822, or, *twenty-one years ago,* it has never required any repairs whatever, and is, at this moment, in excellent condition.

Since a considerable part of the expense and trouble of laying pavements of dressed stone in the diagonal manner, arises from the necessity of cutting, and fitting, triangular closers next to the gutters, it is worthy of consideration, on the part of those who have charge of the highways, whether this may not be wholly avoided, and the general pavement cheapened, by employing next to the gutters on both sides, a band of pebble paving, about two feet wide, which would economically obviate the difficulty referred to; and yet in a 26 feet carriage way, (if we allow two feet for both gutters,) a width of 20 feet of dressed stone pavement would still remain in the middle, to carry the travel of the street.

Although, for apparently sufficient reasons, we have reluctantly declined recommending a foundation of concrete, for pavements of the first class, nevertheless, if there be any single square of leading thoroughfare within the city, where all the iron, gas and water, pipes are laid, the private attachments to them all made, and the sewers completed, so that no necessity of disturbing the street is likely to occur for many years, *then, in such case, it may be advisable to lay a dressed stone pavement upon a uniform foundation of good concrete, at least one foot in thickness,* since there can be no doubt, whatever, that a pavement laid upon such a foundation, if well underdrained, would be as durable as the materials composing it, whilst few, if any, repairs would ever be required, until, in future time, complete renewal should become necessary.

The positive tone in which we anticipate great durability for a suitable pavement laid upon a well underdrained bed of good concrete, is amply justified by the experience upon the Highgate Archway road, at London, which, under the skilful management of Telford, was, by the judicious employment of concrete foundations, in a place far more unfavorable than any which exist here, converted from one of the worst, into one of the best, and most durable, roads within the limits of the British Empire.

* *Hexagonal bricks* have the most suitable figure for the purposes of paving flatwise since they may be so laid that none of the sides will be parallel to the line of travel, and thus secure the advantages of the "herring-bone" disposition; whilst, at the same time, from their form in plan, they resist tilting, and are but little liable to the breakage which may be witnessed in all old pavements, where bricks of the usual figure are employed.

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Prior to concluding this report, it has occurred to us, that it would be proper to speak more specifically upon the subject of the drainage of Philadelphia; it appears from an approximate soil map, prepared at our request, by the assistant city surveyor, with the aid of an officer of the gas works, well acquainted with the various soils underlying our pavements, that a considerable portion of Philadelphia is built upon a sandy loam of such porosity that it drains with facility to lower levels, any water which may be thrown upon it, and preserves naturally a comparatively dry surface.

Another considerable portion of the city stands upon made ground, scarcely more retentive of water than the sandy loam above referred to.

Of course, then, in the districts distinguished upon the soil map by this porosity, *underdrains* to prepare the ground for the reception of pavements, will scarcely be necessary; but they may be confined with advantage—at least for the present—to the clay district, where the subsoil is retentive of water, and, therefore, needs underdrainage before it can form a suitable foundation for a pavement of any kind.

The soil map which we submit, is merely approximate in its character, and being solely designed to carry *a general idea* of the character of the soils immediately underlying the pavements, it will require verification, before it can be safely made the basis of a system of drainage.

Inasmuch as the whole city reposes upon a substratum of open gravel, at a greater, or less, depth beneath the surface, and as this porous stratum is pierced, in almost every instance, by the old public wells, now abandoned, and arched over; it is worthy of consideration whether these wells cannot be made to subserve, to some extent, the purpose of underdraining the highways, since this is a mode of drainage often successfully resorted to in the cellars of buildings here; and it has also been found very satisfactory in draining ground, upon a large scale, for agricultural purposes, many years ago, in England, as may be ascertained by reference to Johnson's able treatise upon *Drainage.*

Finally, having now discussed most of the subjects to which we had proposed to direct our attention, we may conclude by expressing the hope that some of the suggestions thrown out in the preceding report, may be found useful, and available, by the councils of Philadelphia, in improving the highways of their beautiful city.

By order of the Committee,

William Hamilton, Actuary.

Philadelphia, June 26th, 1843.

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Civil Engineering.

Experiments on Water-Wheels, having a vertical axis, called Turbines. By Arthur Morin, Captain of Artillery, Professor of Machinery in the School of Artillery, &c. &c. *Published at Metz, and Paris,* 1838.

(Translated from the French,* by Ellwood Morris, Civil Engineer.)

I.

Of the different attempts made to improve Water-Wheels with vertical axes.

Amongst the attempts made, for some years past, to improve hydraulic motors, the one most remarkable for its success, is that of M. Fourneyron, Civil Engineer, who, with that perseverance and firmness which leads to the end, has succeeded in giving to those wheels with vertical axes, which we call *turbines,* such forms and proportions as make them valuable motors in many departments of industry.

Wheels with vertical axes, have, for a long time, been used in the Pyrenees; and the mills of Toulouse, described by Bélidor, offer a remarkable example of their present application to the grinding of corn. But these wheels, where the water enters, and leaves, by the exterior circumference, after having acted on it merely by its concussion,† do not realize, in the most favorable circumstances, more than $\frac{35}{100}$ of the power expended by the motor. This is confirmed in the experiments made in 1821, by Messrs. Tardy and Piobert, officers of Artillery; many of which will be given further on. Other wheels of the same species, established at Metz, about three centuries ago, and some of which still exist, are far from producing as much effect as those of Toulouse, and from the observations made in 1825, by M. Poncelet, on their product in grinding corn, they do not realize more than $\frac{1}{17}$th of the power expended.

M. Navier, in his notes on Bélidor's Hydraulic Architecture, has given the theory of these wheels, as well as that of one kind of wheel with curved buckets, receiving the water without shock, and letting it escape without velocity, after descending from a certain height upon the wheel following the surface of the buckets; and he has also examined the case where the water entered nearer, or farther, from the axis, than it left it. This last theory, which applied to the numerous *reaction wheels* then known, or proposed, is equally applicable to the turbine of M. Fourneyron, whilst equating to zero the full length the water traveled upon the wheel.

* Throughout *the text* of this translation, I have converted the French, into English measures; but in *the tables,* as they, in part, exhibit *ratios* which would not be altered, whilst the rest of the results tabulated, would have been much encumbered by fractions, it seemed more advisable *to retain* the French measures in these tabular statements. The *metre* is 39.371 *English inches.* The *kilogramme* 2.20485 *English pounds avoirdupois.* To *approximate* the details of any of the experiments, it will be found very convenient to call the *metre* 3 3-10 feet, and the *kilogramme* 2 1-5 pounds, neither of which values will be much in error, whilst their use very much abridges the labor of reduction to English measures.

† These are what we commonly call tub-mills.—Trans.

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and Engineers, at Metz, had given, in 1826, a description and theory of a wheel with curved buckets, and a vertical axis, analogous to his wheel of the same species, of which the axis is horizontal, and which received the water without shock through many points of its exterior circumference, and allowed it to escape without velocity through the interior.

In 1833, M. Burdin, Engineer of Mines, proposed, and put to work, another species of wheels with a vertical axis, described in the Annals of Mines, third series, vol. iii, and has given to them the name of *Turbines*, which has since been applied to all wheels with vertical axes, capable of moving when immersed in the water, of the lower level.

But it was reserved for the perseverance of M. Fourneyron, who, since 1823, has occupied himself with this question, to attain the degree of perfection to which these wheels have been brought. In a memoir inserted in the Bulletin of the (French) Society for the Encouragement of National Industry, in the year 1833, this engineer has given a description of the wheel which he constructed, and for which he has secured a patent.

Respect for the rights so justly acquired by long labor, will prevent us from giving all the information which we have been able to collect, and of which we owe a part to the engineer, as to the forms and proportions of the wheels which we have submitted to experiment, and, consequently, we cannot compare the results of experiment with those of the theoretical formulas, in which these proportions enter as elements of calculation. But the point of most importance to the arts, is to know what duty we can require of this motor in various circumstances, and the results which we shall give on this particular, will, doubtless, appear sufficiently complete to warrant a positive conclusion respecting them.

II.

Experiments on the Wheels of the Mills of Toulouse.

Before reporting the results of experiments which I have lately made upon the *turbines* of M. Fourneyron, it will not be uninteresting to make known some of those, which, in 1821, had been observed by Messrs. Tardy and Piobert, on the different species of wheels of the mills of Toulouse; and from these we shall select only such as refer to the wheels which performed the best. We know* that the water is conveyed upon these wheels by a kind of pyramidal adjutage, called *the spigot*, and that after having acted by impulse upon the concave buckets of the wheel, it escapes below, and at the sides.† It was important to calculate with care, the expenditure of water made by this kind of orifice under given heads; or, in other words, to obtain its coefficient of expenditure.

These able officers determined this coefficient by observing with

* Bélidor's Hydraulic Architecture, edition by M. Navier.

† These are a species of tub-wheels.—Trans.

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care the time required to empty the basins forming the reservoir above the works, and they have found 0.900 for the mean value in this case. That determined, they were enabled to calculate the expenditure of water in *the spigot* for each height of level, as well as the quantity of *absolute work, or power,* developed by the motor.

As for the *useful effect,* it was measured by the aid of an apparatus similar to the *Brake, or Friction Dynamometer* which M. de Prony proposed and employed about the same time, but which was then unknown to them.

The theoretical formula of the *useful effect* of these wheels given by M. Navier, and by M. Poncelet is,

$$Pv = \frac{1000Q}{g}(V \sin. a - v \sin. c)\, v \sin. c.$$

in which we call, (in French measures)

P = The power transmitted by the water to the circumference described by the point of impact of the mean filament upon the wheel.

Q = The volume of water expended in *one second.*

v = The velocity of the circumference of the point of impact of the water.

V = The velocity of the efficient water.

a = The angle formed by the velocity V with the bucket at the point of impact of the water.

c = The angle formed by the velocity v with the bucket at the same point.

g = 9.8088 metres. ($32\frac{1}{6}$ English feet.)

It follows from this formula that the maximum of effect must correspond to the relation,

$$v = \frac{V}{2 \sin. c.}$$

In the wheels of the mills of Toulouse, we have ordinarily, $a = 90°$, $c = 70°$, or sin. $a = 1$, sin. $c = 0.94$. For that of the New Mill,* on which the experiments were made which we are about to report, the point of impact of the mean filament was at a distance of $1\frac{74}{100}$ feet, from the axis of the wheel.

From these elements, it has been easy to form the following table, which contains the results of these experiments.

* It must be borne in mind that this is a *tub-wheel,* actuated like all such, *by impact only.*—Trans.

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EXPERIMENTS on one of the Wheels of the New Mill at Toulouse.

No. of the exp.	*Weight* of water expended in one second. 1000Q	Tot'l fall.	Absolute *work* of the motor in one second.	*Velocity* of impact of the water on the wheel. V	*Velocity* of the point of impact of the water on wheel. v	Ratio of the velocities $\frac{v}{V}$	*Useful effect* by theory.	*Useful effect* measured by the Friction Dynamometer, or *available work*.	Ratio of the *work available* To the effect by theory.	To the *absol'te work* of the motor.
	Kilog.	Mtrs.	Kilog.	Metres.	Metres.		Kilog.	Kilog.		
1	341.1	4.39	1351	9.08	6.33	0.70	647	214	0.300	0.153
2	338.8	4.32	1318	9.00	6.76	0.75	581	211	0.370	0.162
3	302.8	4.26	1290	8.94	6.09	0.68	567	402	0.700	0.312
4	301.4	4.23	1275	8.91	5.76	0.65	581	408	0.700	0.320
5	299.0	4.17	1248	8.84	5.66	0.65	539	421	0.770	0.330
6	295.0	4.07	1201	8.73	5.76	0.62	539	352	0.650	0.293
7	294.0	4.04	1187	8.69	4.76	0.54	566	479	0.840	0.403
8	291.0	3.96	1151	8.60	4.99	0.58	543	451	0.830	0.393
								Mean,	0.750	0.342

[In the above table the absolute work, or power, consumed by the motor, is calculated by multiplying together the second and third columns, or is, in fact, *the weight of water descending one metre in one second,* (and, excepting the first and second experiments, which have been rejected on account of some irregularity) the other columns sufficiently explain themselves.—Trans.]

III.

Deductions from the results contained in the preceding table.

An examination of this table shows that for the values of the velocity v of the point of impact, or introduction, of the water on the wheel comprised between 54 and 68 *per cent.* of V, that of the effluent water, the ratio of the useful effect measured by the brake, to the useful effect by theory, is at an average equal to 75 per cent., and that, consequently, this useful effect will be represented within an eighth by the formula.

$$Pv = \frac{750Q}{g}(V \sin. a - v \sin. c)\, v \sin. c.$$

As for the ratio of the *available work,* measured by the brake, to the *absolute work, or power,* expended by the motor between the same limits, it has for a mean value,

0.342.*

which shows that these wheels return nearly as much (of the power expended) as those of good construction of which the planes of the buckets, and the axis, are horizontal, and which receive the water at the lower part (or, what we call, *undershot wheels.*—Tr.)

The relation,

$$v = \frac{V}{2 \sin. c}$$

which corresponds to the maximum of effect, gives, in the actual case, where $c = 0.94$

$$v = 0.55\, V,$$

* About the same ratio of effect to power, as was determined, for *undershot wheels,* by Smeaton, and others.—Tr.

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values,

$$v = 0.54\ V, \text{ and } v = 0.58\ V,$$

which agrees with the results of theory.

Thus, the experiments of Messrs. Tardy and Piobert, enable us to determine *the useful effect* of a wheel having the buckets hollow, or scooped, and the axis vertical, on which the water acts by impulse within the ordinary limits of velocity, and show that the best of these wheels *do not return more than from* 35 *to* 40 *per cent. of the power expended.*

IV.

Experiments on the Turbines of M. Fourneyron.

General description of the Turbines.—Without entering into the details of the construction, it seems to us indispensible to preface the results of the experiments by a summary description of the machines to which this memoir applies; and we will select for example, *the turbine* established in the furnaces of Fraisans, referring for a more full description, to the memoirs which the inventor has presented to the (French) Society for the Encouragement of National Industry, and which are inserted in the Bulletin of that Society, for the year 1834. The two essential parts of *the turbines* of M. Fourneyron, are *the wheel*, or ring, with curved buckets, and *the sluice.*

The wheel, *a, a,* (fig. 1, 2, and 3,) is formed by an upper ring of strong sheet-iron, and by a ring below, cast in a single piece, with a concave base, which we call *the cap, c, c;* these two rings concentric with the axis of rotation, are placed horizontally, and joined together by the curved buckets, *d, d,* placed vertically, and also made of strong sheet-iron. The *cap* is fixed on the axis of rotation, to which it is firmly bound, and which it carries along in its rotary movement.

The *sluices* consist of a fixed bottom piece, or plate, *e, e,* connected with a hollow cast-iron pipe, which incloses the *main shaft* of the wheel, and is sustained, in the upper part, by wood work, or by supports of masonry. On this plate, *e, e,* rise vertically the curved guides, *f, f,* designed, as we shall show presently, to give to the water the proper direction for issuing from the orifices of emission.

A hollow, cylindrical casting, *g, g,* of which the position is parallel to the axis of rotation, is interposed between the wheel and the directing curves, or guides, and forms the *sluice-gate* properly so called. This cylinder moves concentric to another, *i, i,* which is fixed, and against which it rubs at its upper border, which is furnished with a shield of leather, that prevents the passage of the water when the annular-gate is let down upon the fixed plate, *e, e.* Whilst, on the contrary, if we raise the movable cylinder, or annular sluice-gate, *g, g,* the water runs out between its lower edge, and the plate, *e, e,* and can then enter within the wheel.

The curved guides, *f, f,* are placed in such a manner, that the water enters the buckets of the wheel without sensible shock, and the liquid, receiving on these, a corresponding motion, is directed on the side contrary to the general running motion of the wheel; it results from

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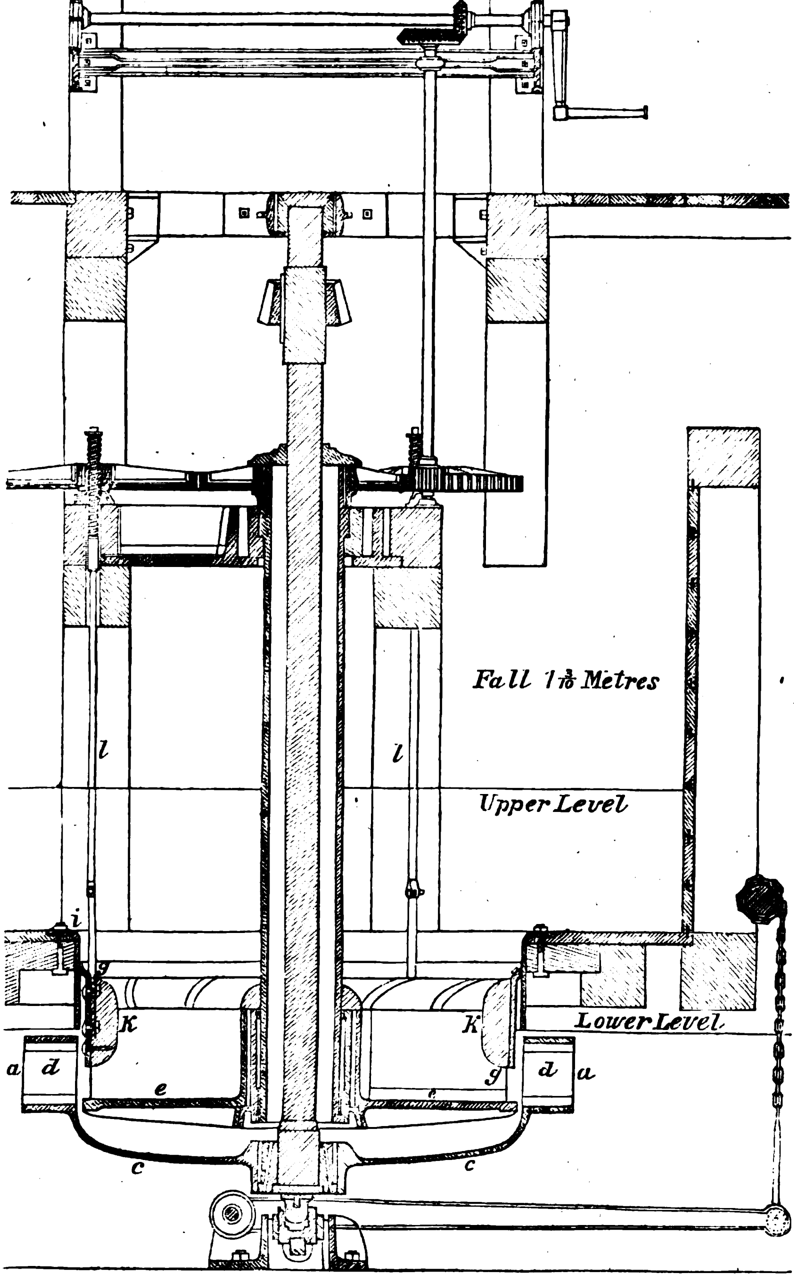

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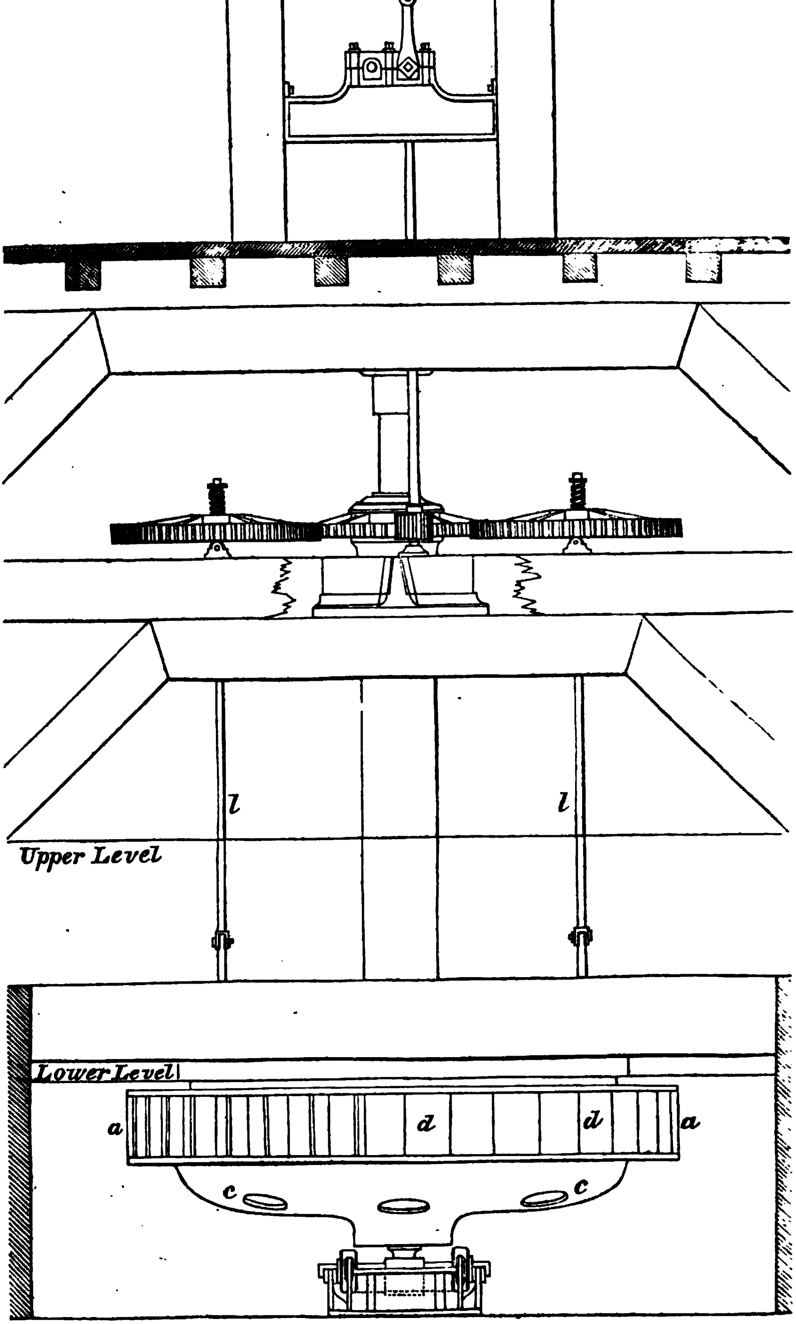

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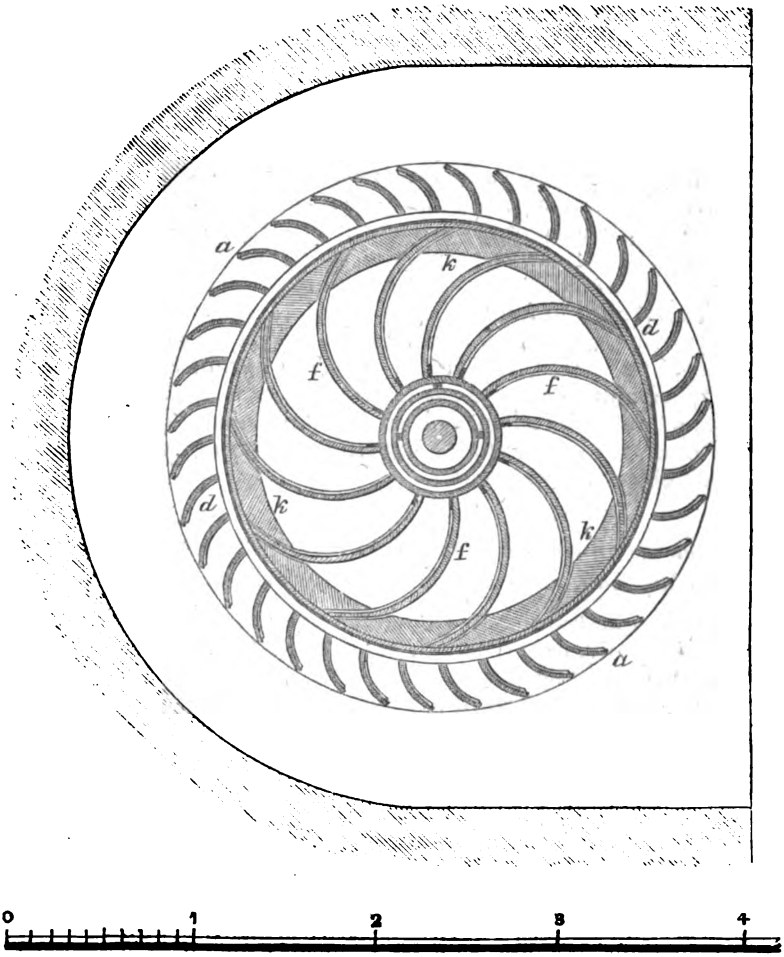
almost no velocity, which satisfies, as we know, the general condition of the maximum effect in hydraulic motors.

Fig. 3.



Scale of 25 millmetres to a metre.

The *wooden cushions, k, k,* fixed to the *sluice-gate,* and slipping between the curved guides, diminish by the rounded form of their lower parts, the effects of contraction, which is, in consequence, nearly destroyed, or at least, very much diminished, on the four sides of the opening.

The motion is transmitted to the *sluice-gate* by *three vertical stems,*

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turn three pinions, all of the same diameter, which act as screw-nuts, and are put in motion by a wheel concentric with the vertical pipe which surrounds the *main shaft.* This ingenious arrangement insures parallelism of motion in the *sluice-gate.*

The *main shaft* passes through the hollow pipe, and has, on its upper part, a cog wheel, which transmits the motion into the interior of the works. At the lower part, this *main shaft* rests in a socket, which we can raise, as required, by the aid of a lever, and which, by an ingenious contrivance, is continually fed with oil, notwithstanding it is immersed in water. The lightness of these wheels, the constant supply of oil, which lubricates the rubbing surfaces, and the proximity of the water which keeps it from heating, remove all apprehension of the pivots wearing out, and the experience of many years demonstrates the excellence of the arrangement. The *turbines* producing a useful effect as great, in proportion to the power expended, when they are submerged, as when they are not, as we shall see further on. M. Fourneyron is in the habit of placing them, so that the level of the upper ring is the same as that of the lowest waters of summer; so that they, at all times, render the whole fall available, which is particularly advantageous at seasons when water is scarce.

As this brief description suffices for explaining the general action of the wheel, we pass on to the experimental results which constitute the chief object of this memoir.

V.

Experiments on the Turbines of the Power Weaving Establishment of Moussay, near Senoues (Department of the Vosges.)

Summary description.—There was established in 1836, in the village of Moussay, near Senoues, in the Department of the Vosges, a Power Weaving Establishment belonging to Messrs. Ed. Laurent & Co., which was put to work in the spring of 1837.

My duty having led me at this time into these works, I availed myself of it to request of the proprietors of this establishment, permission to make some experiments with this motor, from which to deduce its effect. My proposition was cordially received by these intelligent manufacturers, and they had the kindness to make all the arrangements necessary to mount the *brake, or friction dynamometer,* which I sent them. Their works, and their workmen, were liberally placed at our disposal. M. Fourneyron, in person, answered the invitation which was made him, to assist in the experiments; and it is with his aid, that they have been made. The manufacturers and engineers of the neighborhood came to witness, and lend us their assistance in the observations; *they were, consequently, made, and verified, by many persons.*

The motor of the works is a *turbine* of (0.85m.) $2\frac{79}{100}$ feet in exterior diameter, of which the vertical shaft transmits the motion directly to the lying shaft of the weaving mill, by means of a single beveled cog wheel. The water reaches the works by a canal of about (3 m.) $9\frac{84}{100}$ feet broad, and of a regular form, which conducts it into a prismatic

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pipe, communicating by a very short horizontal pipe, with the cylinder which contains the *sluices* of the *turbines.* This cylinder, in which the *sluice-gate* moves, is closed at its upper part, and traversed by the vertical shaft, of which the extremity is of such a height as to allow the lying shaft of the workshop to pass a little below the ceiling of the ground floor. In this way, although the total fall is about $26\frac{38}{100}$ feet, the transmission of the motion is made, in consequence, at any suitable height without hindrance.

VI.

Arrangements adopted for the Experiments.

The *brake, or friction dynamometer,* composed of a cast collar of (0.80 m.) $2\frac{62}{100}$ feet in diameter, turned on its outer circumference, was put on the same shaft as *the turbine,* and the lever, placed horizontally, was supported at its extremity by a cord (6 to 7 metres) $19\frac{60}{100}$ to $22\frac{97}{100}$ feet in length attached to the wood work, in order that it should not bend by its own weight. Over a fixed pulley, placed in a direction perpendicular to that which this lever should preserve whilst it was in equilibrium, passed a leather strap to which was suspended the box that contained the load of *the friction dynamometer.* To make sure that the lever and strap should preserve a perpendicular direction during the experiments, we suspended to a fixed point, a plumb line, below which the middle line of the lever was to be constantly maintained. The perpendicular let fall from the axis of the wheel on the direction of the strap, or the arms of the lever of the load was (2.505 m.) $8\frac{22}{100}$ feet in length.

To insure regularity of friction, we kept the cushion of the *friction dynamometer* constantly wet, in order to maintain the surfaces in the same state of humidity. In consequence of this precaution, the lever remained almost constantly below the vertical of the plumb line, without the oscillations exceeding the space of $\frac{13}{100}$ to $\frac{16}{100}$ of a foot, and without any blows having occasioned violent shocks, as commonly happened when the state of wetness, or oiliness, of the surfaces varied. It also resulted from this continual wetting, that we had not to employ grease in these experiments, and that the temperature of the surfaces in contact, was not elevated even in the greatest velocities, beyond moderate limits, and that to cool them, it was only necessary to continue wetting them during the occasional interruptions in passing from one series of experiments to another.

VII.

Gauging of the volume of water expended.

It was indispensable to give the utmost possible precision to the means employed for gauging the discharge of water through the orifices of the *turbines,* and it would have been troublesome to establish a stop-gate in the tail-race, which is arched, and of considerable depth, but the feeding-race offering, for that purpose, every facility, we placed at its end nearest to the works, a stop-gate with a waste-board of (2.682 m.) $8\frac{80}{100}$ feet wide, of which the vertical edges (of the over-

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fall) distant (0.28 m.) $\frac{82}{100}$ of a foot from those of the canal, had sharp angles, as well as the sill (or edge of the waste-board,) which was (0.60 m.) $1\frac{97}{100}$ of a foot, at least, from the bottom of the canal. The water, consequently, did not reach the reservoir, or *trough*, leading to the wheel, until it had passed over the waste-board, the lower edge of which was never flooded by back water during the experiments.

This arrangement lost part of the fall, and reduced it for the experiments to about (7.50 m.) $24\frac{61}{100}$ feet, ($1\frac{77}{100}$ feet being lost in the clear fall over the waste-board, necessary to render it *a correct meter*.—Tr.) this loss was not productive of inconvenience for the experiments in general; but to be able to make some under the full fall which the works could employ, we subsequently dispensed with the stop-gate, and calculated the expenditure of water by the aid of observations, made during the first series of experiments, proceeding in the following manner.

VIII.

Calculation of the volume of water discharged, based upon dimensions of the openings of the Turbines.

The sum of all the shortest distances measured between the side of one curved guide, and the reverse of the adjacent one, being (0.689 m.) $2\frac{26}{100}$ feet, and the lift of the sluice-gate being known for each experiment; we thence easily deduce the sum of the areas of all the orifices by which the water issues, and, consequently, (knowing the head,) the theoretical discharge. By comparing this theoretical discharge with that calculated from the experiments made with the waste-board, we have deduced for each lift of the sluice-gate of the turbine, the coefficient of discharge belonging to the orifices.

For calculating the discharge of water made by the waste-board, we have used the formula,

$$Q = 0.405\, LH\sqrt{2\,g\,H}$$

where,

Q = Quantity in cubic metres delivered per second.

L = Length of the opening of the waste-board in metres.

H = Depth of the edge below the surface of the reservoir in metres.

We resolved to adopt this formula, because, first, the sides, or borders, of the overfall, were at the distance of (0.25 m.) $\frac{82}{100}$ of a foot, at least, from those of the canal; second, the contraction was almost complete on three sides of the opening; and, third, some part of the furniture of the sluices allowed the escape of a little water which did not act upon the *turbine*. It seems to us, in consequence, that in adopting for the overfall the coefficient 0.405, we have estimated the discharge rather above, than below, the real value.

The following table contains the results of the comparison of the theoretical discharges computed from the dimensions of the orifices of the *turbine*, with the actual discharge calculated by the above formula.

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No. of experiments.	*Sum* of the Areas of the Openings.	*Charge* of water, or difference, of the upper and lower levels.	*Discharge of water in one second.*		*Ratio* of the effective discharge, to the theoretical discharge, or coefficiant. of the discharge.
			Theoretical.	Actual.	
	Sq. Metres.	Metres.	Cub. Metres.	Cub. Metres.	
1	0.0344	7.091	0.405	0.363	0.892
2	0.0337	7.056	0.396	0.362	0.914
3	0.0320	7.160	0.379	0.362	0.954
4	0.0344	7.255	0.411	0.372	0.904
5	0.0344	7.229	0.408	0.364	0.890
6	0.0344	7.131	0.407	0.363	0.892
7	0.0344	6.927	0.402	0.349	0.869
8	0.0324	7.127	0.383	0.373	0.975
9	0.0330	7.313	0.395	0.349	0.884
10	0.0330	7.239	0.393	0.360	0.915
11	0.0330	7.294	0.394	0.351	0.890
12	0.0330	7.134	0.390	0.351	0.900
13	0.0330	7.034	0.388	0.345	0.889
14	0.0330	7.854	0.382	0.348	0.910
15	0.0324	7.395	0.390	0.378	0.970
16	0.0351	7.375	0.422	0.389	0.915
17	0.0351	7.087	0.413	0.375	0.909
18	0.0344	6.911	0.401	0.366	0.910
				Mean,	0.910
19	0.0517	7.278	0.617	0.523	0.848
20	0.0495	7.333	0.593	0.534	0.889
21	0.0544	7.105	0.640	0.540	0.842
22	0.0503	7.285	0.602	0.540	0.896
23	0.0503	7.150	0.596	0.515	0.864
24	0.0489	6.951	0.570	0.523	0.918
25	0.0489	6.986	0.571	0.520	0.910
26	0.0489	7.017	0.573	0.522	0.909
27	0.0489	7.019	0.574	0.512	0.891
28	0.0489	7.002	0.573	0.458	0.799
29	0.0489	6.994	0.572	0.512	0.894
30	0.0489	7.046	0.575	0.515	0.895
				Mean,	0.880

IX.

Deductions from the results contained in the preceding Table.

We see by this table, that the coefficient of discharge, which, for a lift of the sluice-gate of (0.050 m.) $\frac{16}{100}$ of a foot, is at a mean equal to 0.910, reduces itself to 0.80, when the lift is made equal to (0.071, or 0.073 m.) $\frac{23}{100}$, or $\frac{24}{100}$, of a foot. This diminution is one consequence of the arrangement of the orifices of emission, which do not occasion much contraction either on the bottom, or on the vertical sides, and of which the upper side is furnished with a cushion of wood rounded on its inner angles, which gives its proper direction to the fluid vein before it reaches the orifice. For the smallest lifts of.

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ments issue horizontally, and do not undergo, at the sides, any other contraction than what proceeds from the convergence of the curved guides, so that this orifice is analogous to that of the conical, or pyramidal adjutages, (see page 235) and it explains how the coefficient of the discharge can become as great as 0.91.

In proportion as the sluice-gate is raised, the cushion having less influence on the direction of the fluid filaments, the contraction on the upper side of the orifice is not so completely annulled, and, therefore, the coefficient of discharge gradually diminishes with the lift of the *sluice-gate*, until that lift becomes equal to the height of the *turbine*.

We shall see farther on, by the observations made on the *turbine* of Mülback, that this induction is completely verified.

These observations accounting very well (as it seems to us) for the variations of the coefficient of discharge of these orifices, enable us to calculate by interpolation, the value of the coefficient of the discharge, in the cases where the lifts of the sluice were (0.86, and 0.107 m.) $\frac{28}{100}$, and $\frac{35}{100}$ of a foot, with which only we have worked, whilst omitting the gauge by the overfall, or waste-board.

In making the calculations, we have assumed, that within limits as narrow as those of our experiments, the decrease of the coefficient was proportional to the differenee of the lifts of the *sluice-gates*, which evidently could not lead to any appreciable error. It is upon this basis, that we have adopted for the coefficient of the discharge corresponding to a lift of the gate of (0.086 m.) $\frac{28}{100}$ of a foot, the value of 0.86, and for a lift of (0.107 m.) $\frac{35}{100}$ of a foot the value 0.83.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 174.]

SECOND COURSE—LECTURE XIV.—WORKING EXPENSES OF RAILWAYS.

Mr. Vignoles commenced by reminding the class, what he hoped they duly felt, that the great object he had in view during the present course, was to consider, in every bearing, the proportion between the cost and expenditure upon any work, as compared with the probable profitable returns. Although this consideration, and that of the good result of any such speculations, might be thought not to come strictly within the duties of an engineer, and, until of very late years, had been neglected, and, in some striking eases, absolutely repudiated, by eminent men, yet Mr. Vignoles was of opinion that it must ever be kept in view, and should absolutely form a branch of the engineer's study, for he ought to feel that any works he may be called on to construct, should not only be such as will reflect credit on him as a professional man, for design, arrangement, and execution, but, as the Professor had often urged, such as, in this commercial country, where private enterprize and speculation attempts, and effects so much,

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will, by their success, prove the accuracy of his judgment, and his capacity, as an adviser, to lead spirited undertakers into future operations of the same kind. In short, that the success of an engineer depends, perhaps, more on the beneficial results of his works to the proprietors, as commercial speculations, than on his own masterly conquest by art over natural difficulties. But the engineer should further look at this subject in a higher point of view, and consider that all unprofitable expenditure is so much waste of the resources of a country, and that, of all professions in society, his is the one most called upon to direct the laying out of large sums on what may truly be considered national objects, for the judicious and beneficial results whereof he is responsible, and, consequently, whereon his reputation must ultimately depend. Referring to an expression in a late lecture, the Professor observed, that he by no means intended to represent that it was not necessary, in the construction of railways, to reduce the natural undulations of a country to uniform inclinations, but that it was to be maturely considered at what cost such advantage is to be acquired, keeping constantly in view a comparison of this cost with the working expenses of a line more or less perfect. It was the investigation of these *working expenses* that was now to be entered on. In proceeding to do this, Mr. Vignoles observed that he considered it by far the best way to reduce to a mileage, not only their gross sum, but also each of the items, these being again subdivided as far as possible. By a "mileage," he understood the result arising from dividing the periodical amount of the expenses by the total number of miles run by locomotive engines *with trains after them.* The Professor insisted that this was the proper way, and gave a number of reasons for his opinion, and for not at all considering the expenses with reference to any proportion they might form of the gross receipts—the two sources of income and expenditure being perfectly independent of each other; and Mr. Vignoles further thought this mileage comparison was the only one from which correct results could be drawn, and whereby materials and experience might be collected, so as to result in the practical benefit of companies being able, before long, to enter into contracts for most of the items of expenditure at given rates. Some companies had already contracted with each other for the supply of locomotive power, carriages, &c., at a mileage; the maintainance of the way was now almost universally paid for by the lineal mile of rail, and he had no doubt, but that, after a little more experience, other of the working expenses of railways would form subjects of such a kind of contract.

Mr. Vignoles then proceeded to enumerate the general heads of these expenses, viz., 1, *locomotive power*, subdivided into drivers' wages, fuel, oil, hemp, &c., ordinary repairs, water, and fuel stations, reserve fund; 2, *carriages;* 3, *maintenance of line;* 4, *police;* 5, *conducting traffic and stations;* 6, *rates and taxes;* 7, *government duty;* 8, *miscellaneous charges;* 9, *management.* These were the proper items, exclusive of interest on loans, which, although to be deducted before a dividend could be made, of course, formed no part of the positive working expenses of a railway. The Professor then

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various gradients, explaining the reasons of excess, or of diminution, in one, or other, item on the respective lines, exhibiting also comparative tables, and making many valuable observations upon obtaining the best attention, and greatest economy from the servants of a public company, by instituting premiums graduated in proportion to the diminution of annual working expenses.

Locomotive power.—In considering this item, Mr. Vignoles showed, from an average of a number of lines, where the arrangements were properly established, and the railway had been long enough at work to have got all matters systematically arranged, the subdivision per mile per train might be taken as follows—viz., wages, 2*d.;* fuel, 4*d.;* oil, hemp, &c., 1*d.;* making 7*d.* per mile as the mere cost of motion, exclusive of repairs of any kind. This might be considered as applicable to an average of six or eight carriages per train. Heavier trains only came occasionally in the course of the 24 hours, and unless upon lines having exceedingly favorable gradients, auxiliary engines were then applied, the cost and mileage of which being included in the annual accounts, the above rate of calculation would still apply. On railways not having a very considerable traffic, the number of carriages, on the average, were fewer than above stated, and the engine and tender might be fairly taken as constituting half the gross load of each train. The items of wages, and oil, hemp, &c., would not materially vary on different lines, except, perhaps, the first, or on short lines with very great traffic, with quarter, or half-hour, trains, such as the London and Greenwich Railway, the Dublin and Kingstown, &c. The fuel would be a variable quantity, but it would rarely exceed 6*d.* Next must be taken the ordinary repairs, and the Professor stated that in no case was the old adage of "a stitch in time" so applicable, as in a constant vigilance, and daily inspection, and remedy, of the smallest defect in locomotive engines. A plentiful stock of engines of the very best materials and workmanship, and an efficient and roomy repairing establishment, though somewhat costly at first, would be found to be the means of keeping down the expense of repairs to a low figure. The amount of this item spread over a year's working appeared to average, on well regulated lines, about 7*d.* to 8*d.* per mile; some instances had been as low as 6*d.* The expense of water and fuel stations varied from ¼*d.* to ½*d.* per mile. The reserve fund was an arbitrary charge; Mr. Vignoles assumed that about 10 to 15 per cent. on the ordinary repairs would be sufficient—say 1½*d.* Thus it would seem that the total cost of locomotive power ought to be about 15*d.* or 16*d.* per mile per train. In some instances it had been reduced so low as 1*s.*; in others this amount had swelled to 18*d.*, and even up to 2*s.*

Mr. Vignoles then analyzed the other heads of the working expenses—viz., carriages, which he seemed to consider an expensive item, varying from 4*d.* to 6*d.* per mile per train—say from ½*d.* to 1*d.* per carriage per mile, including the various descriptions of vehicles for passenger traffic. The maintenance of the railway varied most

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remarkably, from 2*d.* per mile per train (which had been the cost on the Dublin and Kingstown Railway and was now even lower, and Mr. Vignoles believed that on the Greenwich Railway this was also a small item, since they had replaced their stone blocks by timber supports), up to 1*s.* per mile per train, which was the cost on several lines; but, on a railway with the upper works properly constructed, he thought that 6*d.* to 8*d.* per mile per train ought to keep a double road in good order, including a reserve, or depreciation, fund for renewing the iron rails—a contingency that should by no means be lost sight of. The Professor here made a long digression on this item, as to how much of the cost should be assigned to atmospheric causes, and all collateral and contingent circumstances; how much to the mere dislocation of the upper works; and how much to the positive wear and tear of the iron; and pointed out some remarkable instances of saving in maintenance, where the longitudinal timber bearings had been adopted. The charge of police varied from 1*d.* to 6*d.* per mile per train, according to the vigilance exercised; in placing 2*d.* per mile as an average, it was to be considered only as an approximation. Conducting the traffic and stations was an item that did not seem to differ much on the various lines; for the passenger department it appeared to be about 5*d.* Local rates and taxes would, of course, vary materially; the poor rate formed a serious charge on all railways; this item was indirectly contingent on the actual profits of the company; it appeared, however, to be seldom less than 3*d.* per mile per train. Government duty had heretofore been computed at ⅛*d.* per passenger per mile—henceforth it was to be calculated at 5 per cent. on the gross receipts for passengers only. This would, of course, make greater discrepancies; still, as the new duty on the gross was estimated to be equivalent to the old duty, an account might be obtained if the number of passengers per train were known. Assuming this number to average forty, taking all the railways of the United Kingdom, the government duty might be estimated at 5*d.* per mile per train. Taking a mean of four or five railways, the miscellaneous expenses were found to be about 2*d.*, and the management about 3*d.* per mile per train. Now, to make a summary of all these, which was, however, to be taken generally, and, of course, liable to be effected in the details, but was still interesting to be submitted in a popular form, and might be useful as giving a comprehensive view of the system;

Abstract of the average working expenses of a railway per mile per train.

	s.	d.
Locomotive power—viz., wages, 2*d.*; fuel, 4*d.*; oil, hemp, &c., 1*d.*; ordinary repairs, 7*d.*; water and fuel stations, ½*d.*; reserve fund, 1½., - - - - - - - - -	1	4
Carriages, - - - - - - - - - - -	0	4
Maintenance of line, - - - - - - - -	0	8
Carried over, - - - - - - - - - -	2	4

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Brought over,	2	4
Police,	0	2
Conducting traffic and stations,	0	5
Local rates and taxes,	0	3
Government duty on passengers,	0	5
Miscellaneous expenses,	0	2
Management,	0	3
Total,	4	0

Mr. Vignoles did not, by any means, pretend that this was other than a probable approximation. Some lines had been worked at a lower rate per mile per train, including all the above expenses; for example, the latest accounts of the North Union Railway, show the cost to have been only 3*s.* 4*d.*, not including any funds for reserve. The Professor himself thought that 3*s.* was a fair sum, exclusive of taxes and duty, which, however, together form a large proportion of the expense. On the other hand, there were instances in which the expenses had gone up to 5*s.* per mile per train. He considered it would be a great public benefit if all railway companies, in their reports, would give fuller details of the working expenses, and state the number of miles run *by trains*. Some few Boards set a very good example in this respect. This was sometimes done for locomotive power, but the miles should only be computed as actually run with the trains, and not to include the various extra distances passed over in manœuvres, piloting, signals, &c., which though necessary, were not part of the actual mileage of trains.

The Professor then drew the attention of the class to the fact, that the locomotive power formed about one-third of the gross expense, and of that one-half only is likely to be affected by the gradient, or load, being only one-sixth of the whole of the working expenses, which was but a small item upon which a saving was to be made, to justify a railway being constructed theoretically perfect, unless the traffic was likely to be continued, regular, and very heavy. He further observed, that though he had proposed, for the sake of an easier comparison, to reduce all the items of the working expenses of a railway to a mileage per train, it was manifest that a considerable addition to the number of trains daily, and, of course, to the number of miles run, would very materially affect the locomotive power only. The taxes would be contingent on the receipts; and all the other items would be increased but in a very small degree, on the annual totals, by an increase in the number of the trains, with a carriage or two less at a time. It was important to remember this, as it affected greatly the question of laying out railways. Mr. Vignoles insisted that the extension of railways in England, especially in remote districts, would not be carried into effect until this subject had been more closely analyzed, and had become better understood. Looking at the practical working of the Newcastle and Carlisle, the North Union, the Manchester and Leeds, the Sheffield and Manchester, as

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contrasting their working expenses with those of lines whose inclinations were much more favorable, the average cost per train per mile did not vary greatly. Lines which had been formed at a cost of from £50,000 to £60,000 per mile, a large portion of which was to obtain perfect gradients, seemed to require little less to work them than lines costing only one-third to one-half that sum. It is true they might be able to carry heavier trains, and did so carry them occasionally, but the average was very nearly what had been stated, and, besides, the public were best accommodated by lighter trains going more frequently. The Professor said, he could only hope that his arguments would draw attention to the subject, and that when, after the analysis of the cost of all the railways had been brought out in the way shown in his last lecture, and that of the working expenses, as in the present one, materials would be obtained for the solution of the problem, of what must be the rule for constructing lines of passenger railways hereafter.

(To be continued.)

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Injury done to Roads by the Passage of Carriages.

An able report* has lately been made to the French Chamber of Peers, by the Minister of Public Works, M. Teste, on the maximum load which carriages should be allowed to draw on the roads constructed by the government. In contains, as its basis, a clear and minute account of a series of experiments, performed by M. Morin, during a period of several years, to ascertain the manner in which the injury done to roads, by the passage of vehicles, depends upon the dimensions of those vehicles, and on the loads which they carry. These experiments are not yet generally known, and they seem so valuable, on many accounts, to both the engineer, and the machinist, that some extracts from the report of M. Teste, may be acceptable to our readers.

But besides the experimental results themselves, and apart from the subject upon which they directly bear, there is one point suggested by the reasoning of M. Morin, of so great interest, as to warrant an extended notice. This is the relation between the deterioration of roads, and the resistance to the motion of carriages, or, to state it in a more general form, between the injury, and the contemporaneous friction. The evident advantage in almost every department of the arts, of the determination of this relation, is sufficiently obvious; but the inquiry assumes a graver importance from the singular and violent contradictions which it discloses between the received laws of friction, and the facts which have been observed. Whenever such differences occur, it is natural to wish to reconcile, or explain, them, and this becomes absolutely necessary in a question of such immediate, and practical concernment as that of friction. As the limits, however, of

* Addition à la Séance de Mercredi, 10 Mai. Moniteur 14 Mai, 1843.

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problem, we can do scarcely more than submit to the consideration of engineers, a purely theoretical formula, which both explains the anomalies hitherto observed in the laws governing the attrition of bodies, and contains the relation between the deterioration, and the friction, of which we have spoken.

It is, in the first place, evident that the injury done to any body by the action upon it of any other body moving over it, must be proportional to the force, or power, expended in producing it. This force is of two kinds—one, a part, or a function. of the force of gravity, or the weight, of the moving body; the other, the force necessary to overcome the resistance in the direction of the motion, occasioned by the inertia and cohesion of the opposing particles of the stationary body, and to tear them off, or separate them. Representing the first force by fP, and the second by R, we shall have for the expression of the injury, $M\ (fP+R)$, M being a coefficient depending upon the nature of the rubbing surface. But if we should adopt a very common opinion as to the cause of the friction, and believe it to be solely the opposition of the projecting particles of the surface, upon which any body moves, so that these particles must be broken off, and cast aside, in order to admit of motion, we shall evidently have, as a formula, for the friction, $F=R$. Now, it is perfectly plain, that whenever M and fP are constant, any increase, or decrease, in the injury, must take place in the term R; R, therefore, will, in this case, vary when the injury varies, and, consequently, the friction which is equal to R, will vary when the injury does. But the experiments of M. Morin, in 1837, will be seen, hereafter, to prove that the injury increases when the velocity increases; the friction then should likewise increase with the velocity, and yet M. Morin has shown, from his experiments in 1831, reported in the Memoirs of the Academy of Sciences, for 1833, and since in this Journal,* that the friction does not change with any alteration in the velocity.

Here, then, occurs that violent contradiction between theory and experience, to which we have alluded—a contradiction only to be explained by the insufficiency of the one, or the incompleteness and inaccuracy of the other. It is most natural to suppose that the theory is defective, and that some other cause concurs in producing friction besides the mere resistance of the particles of the rubbing surfaces. If this is actually the case, the expression for the friction will no longer be R, but of the form $X+R$, and then it is evident that an increase in the value of R so great as to cause a very marked variation in the injury, may only occasion an almost imperceptible increase in the friction, so that it might easily be overlooked by experimenters.

To discover, then, this additional cause, or, perhaps, causes, and to derive from thence a complete theoretical equation for friction, let us suppose that the body A, is drawn over the body B; that the friction is to be measured by the force of traction continually necessary to maintain an uniform motion; and, finally, that B is of such hardness, or consistence, that A cannot sink farther than its own height into B. The definition given to the friction, is the one generally used, and the

* Vol. x; 2nd, series, p. 285.

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last supposition is made solely to simplify the question. Now, there may be, and there usually are, with the substances in common use, three different causes of friction, or, of the resistance to motion—one already mentioned, the direct opposition of the particles of the body B, which A, in its motion, tends to break off, or plough up, or divide, in order to move; the second, the resistance occasioned by the shocks which the roughnesses of B must produce, if they do not give way to A; and the third, that disclosed by the elegant hypothesis of Euler, (Mem. Berl. Acad., 1748, p. 125,) an hypothesis, which, like most of the works of that great mathematician, has been too much neglected by subsequent theorists. We shall consider these separate causes in the inverse order to that in which they are named.

The conjecture of Euler is somewhat similar to that of M. Parent, but much more simple and natural. It consists solely in supposing that the little projections, or roughnesses, which exist on the surface of every body, form a complete succession of inclined planes, up which one body moving over another must be forced. Now, it is perfectly evident, that more power will be needed to draw a weight up an inclination, than along a perfectly level surface, and this additional power required, is, according to Euler, the whole of the friction. To make this clearer, imagine the plane B, to be placed horizontally, and made perfectly smooth and hard, (for, although this is not possible in reality, it is so in imagination,) and let the body A be drawn over it: it will at once be seen that there can be no resistance to the motion, and that any, the least, power will be sufficient to move it. Imagine again, that B, although still remaining perfectly hard, is not entirely smooth, but covered with a succession of minute, and similar elevations, or inclined planes. The whole resistance now will amount to the force necessary to compel A, resting itself upon small projections of its own, to ascend any one of these little inclinations of B.

The power, then, required to move A forward, or the resistance, or the force of traction, or the friction, for these are all equal in quantity, will depend, in the first place, upon the weight of A, or upon P; in the second, upon the nature and form of these minute elevations. It may, therefore, be represented by C.P, in which expression, C is a variable function of the nature of the substance of the body B. As we shall hereafter see that this expression does not represent the whole of the friction in all cases, nor, indeed, in general, we may designate the portion which it does represent, by F′, whence results the equation,

$$F' = C.P. \qquad (1)$$

When the body A has thus ascended one of the inclinations, the little projections of its own, on which it is supported, have to descend into the hollow between the similar projections of B, in the same way that cog-teeth fit into each other. In the course of this descent the force of gravity, and the velocity combined, drive the projections of A against those of B, and this shock acting obliquely to the direction of the motion, impedes the progress of A, and constitutes, therefore, a part of the resistance. It may be represented by D.P.v, where v is

B, and of the angle which the line of draught makes with the plane of B. We have, therefore, for the effect of the second cause of friction,

$$F'' = D.P.v. \qquad (2)$$

As the hypothesis of Euler, however, and the conclusions deduced from it, imply a degree of hardness in the body B, sufficient to enable its little projections to preserve their form against both the pressure of the imposed weight, and the shocks which they suffer, this hypothesis will not be sufficient to account for the resistance when B is composed of any yielding substance. To discover an expression for the additional friction produced in this case, we must resort to the supposition of another cause—the cause, in fact, which was mentioned at the outset.

Imagine, then, the plane B, to be composed of matter not possessing cohesion enough to prevent the body A from sinking partly into it. According to this hypothesis, A, in its motion, will tear up, and either carry alon gwith it, or cast aside, some part of B, and the power expended in doing this, is evidently equal to that part of the friction which is due to the direct opposition of the particles. In order to estimate its amount,

Let h represent the force of cohesion of the material of B, or the weight which B can support upon a square foot without yielding.
d, the depth, or thickness, of A.
b, the breadth.
mb, the length.
v, the velocity.
P′ the weight pressing upon a square foot of the lower surface of A.

Then the friction arising from the cause just mentioned, will be proportioned:

First, to the depth to which A will sink into B. Let this depth be x, and x will depend upon the weight which causes the sinking. The weight on a square foot effective for this purpose, is the difference between the actual pressure P′, and the quantity h, which B is capable of sustaining by virtue of its hardness; it is therefore, P′—h. If there was no other force to oppose this, and if P′ were greater than h, the body A would sink entirely through B. But every substance in nature becomes more compact by compression, so as to be able to support weights indefinitely great. Suppose, therefore, that B increases in density, and hardness, in such a manner that its supporting power at any small depth as x, may be represented by $h+(fh)x^z$, (fh) being a function of h, and z, the exponent of the power designated by the law of the increase. We shall now have $h+(fh)x^z = P'$, or $x = \sqrt[z]{\frac{P'-h}{fh}}$. Introducing the value of P′, or $\frac{P}{m.b.b.}$ the equation becomes,

$$x = \left(\frac{P - m.b^2.h}{m.b^2.fh}\right)^{\frac{1}{z}}.$$

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tional to the force of cohesion h of the particles, which the body A has to tear apart in its motion forward.

In the third place, the resistance would vary exactly with the breadth b, (since the greater the breadth, the more particles must be torn up, and pushed forward) if it were not for one remarkable circumstance. When A has separated in its motion, the molecules of B, it generally throws them on one side, as a plough would do, else it would have to force along in front of itself, a strip extending the entire length of B. Now it is evident that the broader the front surface of A is, the more difficulty will there be in throwing the molecules completely to one side, and the longer will it take to do it, so that the number of particles which have to be carried along in front of A, before being thrown aside will increase, and, therefore, the resistance will increase with an increase in the breadth. The resistance is not then exactly proportioned to the first power of the breadth, but to something more, to b^{1+n}, b^{n}, representing the increase in the resistance arising from the circumstance just mentioned. In air, n has been found to be about $\frac{15}{100}$; in water, about $\frac{2}{10}$. In sand, which is a semi-fluid, it may, perhaps, be called $\frac{1}{5}$.

In the fourth place, the resistance varies with the first power of the velocity, when the definition for friction, which we have adopted, is used; for the greater the velocity of A, the greater likewise will be the force with which it strikes the particles of B, the greater, consequently, the reaction upon A.

Uniting these separate modes of variation, that part of the resistance, or friction, which is the result of the cause which we are now considering, will be represented by $E.x.h.b.^{1+n}v$, E being a coefficient to be determined for each substance by experiment. Substituting the value of x, and reducing, we shall have the equation,

$$F''' = E.\left(\frac{P - m.b.^2h}{fh.mb^{2-z-nz}}\right)^{\frac{1}{z}} h.v.$$

And making $z = 1$, which is the most natural supposition at small depths.

$$F''' = E.\left(\frac{P - m.b.^2h}{fh.m.b^{1-n}}\right). h.v. \qquad (3)$$

This equation represents the amount of friction derived from the direct opposition of the particles, to a force tending to break them apart, and plough them up. But in no substance, with which we are acquainted, and especially in no granular material, will this be the only cause of resistance to motion. For, suppose that the body A has sunk to any determinate depth in B, it will then rest upon a bed of minute molecular projections, or grains, or inclined planes, similar to those over which it would have to pass upon the surface of B, if it did not sink. Besides, therefore, the force necessary to push a bulk of matter before it proportional to the depth sunk, two additional forces must be employed, or expended—one, to draw A up these little

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inclinations; the other, to supply the power lost by the shocks. Each of these forces is the measure of an additional portion of the friction, the first, as we have seen, being represented by F′, and the second by F″, so that the hypothesis of Euler, and the common one, are not contradictory, but equally probable, and they should be considered together, and not separately, when we would account for the effects of friction. We ought, then, to make the entire resistance from friction the compound, or sum, of these three resistances, which we have analyzed, and to establish for the final equation,

$$F = F' + F'' + F''' = C.P. + D.P.v + \frac{E.(P - m.b^2h).h.v.}{fh.\, m.b^{1-n}} \qquad (4)$$

It would exceed the limits of this article, to compare this equation in all points with experimental results, or to enter into the complex analytical investigation necessary to determine the values of the variable coefficients, C. D and E. It is sufficient that these contain no terms which can materially affect the conclusions which we wish, at present, to draw.

I. When $h = P'$, or $P = m.b^2h$, that is, when the cohesion, or hardness, of the surface of the body B, is sufficient to support the weight P without any alteration in its particles, the third term will vanish, as it is natural to expect, and then $F = C.P + D.P.v$, or rather inasmuch as on a comparatively smooth surface, and with small velocities, $D.P.v$ will be very small, with relation to the first term, we shall find very nearly $F = C.P$, the second member of which contains no factor of the surface, or the velocity. The friction, is, then, proportional simply to the pressure, and this theoretical conclusion is abundantly confirmed by the experiments of Coulomb and M. Morin, with *hard* and *smooth* substances.

II. When $h = o$, inasmuch as the variable coefficients C and D must contain h as an implicit factor, the three terms vanish, and $F = o$, as in a vacuum, and approximately in the air.

III. When the quantity $m.b^2h$ holds, as in all yielding substances, an intermediate value between P and o, the friction will increase when the velocity increases, and will decrease with the breadth, of the surface; and this has been very clearly shown to be the case, by the experiments of Vince, Coulomb, Parent, Rennie, and those of Morin in 1838, upon bodies possessing little cohesion in proportion to the pressure. This conclusion, fortified by so many proofs, cannot be invalidated by the experiments of M. Morin in 1831, which were all made with comparatively *unyielding* materials. It is to be noticed, however, that the friction is not exactly proportional to the velocity, but to an expression of the form $1 + Mv$, where

$$M = \left[D.P + \frac{E(P - m.b.^2h).h}{fh.\, m.b^{1-n}}\right] \div CP.$$

Hence, it is evident, that M must be very large, or that CP must be very small, compared with the value which $F'' + F'''$ obtains at a velocity of one foot per second, in order that the friction may be considered proportional to the velocity. But it is easily seen that with

therefore, it is nowise surprising that experimenters upon unyielding substances, have, of late, considered the velocity to have no effect upon the friction.

Having thus seen that the equation (4) is not only probable from theoretical considerations, but also confirmed in its most essential parts by experience, let us attempt to derive from it the relation which the injury done to any body B, by the motion of another body A over it, bears to the friction produced at the same time between A and B, and to this end, let us resume the reasoning which was employed at the commencement. An expression was there found for the injury, such that if we represent it by I, we shall have the equation, $I = M.(fP + R)$, or since, according to the definition there given for R, $F''' = R$, the above equation will become,

$$I = M.(fP + F''') \qquad (5)$$

and substituting the value of F''' in terms of F, F' and F'',

$$I = M.(fP + F - [F' + F'']). \qquad (6)$$

If the values of M, F' and F'', and the nature of the function of P can be determined for the substances in common use, we can likewise obtain the value of the injury I, directly from the measurement of the friction F, so that the wear of machinery, and the deterioration of roads and railways, may thus be estimated in a simple and expeditious manner. As the problem, however, under this general form, is somewhat too complicated for our present limits, let us consider the equation (5) as it becomes when the proper value of F''' is inserted, that is, when

$$I = M.\left[fP + \frac{E.(P - m.b^2h).h.v.}{fh.m.b^{1-n}}\right]$$

It will be seen by a little reflection, that $\frac{P - m.b^2h}{fh}$ is a factor of fP, so that this equation becomes,

$$I = M.\frac{(P - m.b.^2h).}{fh}\left[X + \frac{E.h\,v}{m.b^{1-n}}\right] \qquad (7)$$

X representing the other factor of fP. The injury, therefore, decreases when the surface $m.b^2$, or the breadth b increases, although not in exact proportion; it also increases with the velocity, and when X is 1, or of a value much smaller than $E.h$ (as it must always be), the injury may be considered as increasing proportionally to the velocity. These conclusions, it will be seen, are confirmed by the experiments of M. Morin.

The formulas thus far introduced, are applicable only to the case of prismatic bodies resting upon a plane surface; when the lower surface of the rubbing body is perceptibly curved, as in the case of wheels, some modifications must be made in the expressions for the friction and the injury, which may be briefly noticed. Suppose, in the first place, that the wheel does not roll, but is simply dragged along. The first term of the friction F', will not be altered, but the

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and force of the shock, represented by F''', will vary with the curvature of the striking body, and the coefficient D must, therefore, vary from the same cause, and, with regard to the third term F''', m is a function of the curvature of the increase of density fh, and of the weight upon a square foot P', so that it is only when all these remain the same, that F''' is unaltered.

Imagine, again, that the wheel is rolling. In this case, the modifications, noticed above, are still necessary, and with them some others, of which we need only, for the purpose of determining the deterioration of roads, specify that which takes place in the third term. It is not difficult to see that the part of the force of traction which corresponds to F''', must vary inversely with the diameter of the wheel, for this force acts at the axletree, while F''' acts at the circumference, so that the force referred to, is equal to $\frac{F'''}{\frac{1}{2}d}$. But this explanation does not at all imply that the real friction at the circumference, and, consequently, the injury is diminished by an increase in the diameter, although a little consideration of the subject will show that this is the fact. If a wheel was so low that the resistance from obstacles upon the road, should be in a direction passing through the centre of the axle; that is, if the centre should not be higher than the obstacles, no motion could take place, unless the wheel broke down what opposed it; but if we suppose that the radius of the wheel is increased, and the line of draught, thus made, to pass above the line of resistance, both a rotary and a forward movement would take place—the wheel, that is, would roll up, and surmount the obstacle. This effect would be more likely to occur, as the radius of the wheel was greater, and since it evidently amounts to changing the crushing and tearing action, represented by F''', into the motion up inclined planes, represented by F' and F'', it must cause a decrease in F''', proportioned to the probability of its existence, proportioned, that is, to $\frac{1}{2}d$, or one-half of the diameter of the wheel. The greater, therefore, this diameter, the less will F''' be in the case of rolling wheels, and the equation (5) will become $I = M.\left[fP + \frac{F'''}{\frac{1}{2}d}\right]$, whence, as before,

$$I = M.\frac{(P - m.b.^2h)}{fh}\left[\frac{X + H.h.v}{d.m.b^{1-n}}\right] \qquad (8)$$

H, in this expression, is equal to 2E.

It has already been remarked that m is a function of the curvature, and, therefore, must change when the diameter changes. If we suppose it to increase with the first power of the diameter, it may be represented by sd, s being a coefficient depending upon the other causes of variation. By introducing this value of m, by making $X = 1$, and the exponent $n = \frac{1}{3}$, or $n - 1 = \frac{4}{3}$ (as is the case in sand or gravel), the equation (8) will become,

$$I = \frac{M.(P - sd.b.^2h]}{fh}.\left(\frac{1 + H.h.v}{sd^2.b^{\frac{4}{3}}}\right) \qquad (9)$$

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by the passage of carriages. The most important of the consequences which may be deduced from it, seem to be the following: The injury *increases* with the load P, and the velocity v, although not in exact proportion to the increase of those quantities. The injury also *decreases* when the breadth of the wheel b, or when the diameter d, increases, although not in exact proportion.

These conclusions may be drawn from the simple inspection of the equation. Some of the less obvious results, are, that when several carriages travel, one exactly behind the other, those behind do scarcely any injury, in comparison with the foremost; that when several carriages are loaded with weights proportioned to the breadth of their wheels, those with the widest wheels will do the most injury; and, finally, that when several carriages are loaded with equal weights, the injury will not decrease as fast as the breadth of the wheels. All these theoretical conclusions are confirmed by the experiments of M. Morin, and this coincidence may be considered as a proof of the correctness of the formula. The accuracy, however, of the particular equations, which have been given, is not of so much importance as the soundness of the general method by which they are constructed. This method consists simply in the union of all the causes which can, in any way, contribute to the production of a certain effect, and the combination of the partial effects, which each of the causes would of itself produce, into one expression representing the real, or complete, effect. It is, in fact, an application of the theory of probabilities, the variable functions C, D and E. $\frac{(P-h)}{fh}$ representing, respectively, the probability that F', F'', or F''', will exist, or that the different causes of friction, which occasion those terms, will really act. How far this method may be employed with advantage in physical researches, is a question worthy of some consideration.

The foregoing observations and formulas, will, perhaps, do something to show the importance, in many points of view, of the series of experiments undertaken by M. Morin, by order of the Minister of Public Works, and may serve to clear up some points which those experiments left doubtful. The actual demonstrations of experience, however, are more quickly comprehended, and more easily applied, than any abstract conclusions,) and practical men, therefore, will like to see the results of investigations, conducted with the ability and care which distinguish all M. Morin's inquiries.

"Towards the end of the year 1838," says M. Teste in his report, "and when the last draught of a law upon the regulation of the transport of goods, already adopted in the Chamber of Peers, was about to be discussed, in the committee appointed by that of Deputies, an officer of Artillery, commissioned by the Minister of War, with the execution of some experiments on the traction of carriages, M. Arthur Morin presented a memoir, upon this question, to the Academy of Sciences. In that work, the author arrives at many conclusions, relative to the action exerted by vehicles upon roads, which are the only ones with which we shall here occupy ourselves." [These

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carriages upon roads, are as much greater as the wheels are smaller, (which is not altogether accurate) the resistance upon paved, or solid, macadamized roads is nearly independent of the breadth of the tire; upon such roads, also, even when they are in a very good state, the shocks occasioned by the inequalities of the ground, produce a loss of the velocity, and, consequently, an increase of the resistance, as much more remarkable, as the velocity is greater, and the carriage less elastic;" and, finally, "carriages without springs, going at a walk, injure macadamized roads more than carriages with springs, going at a trot."]

"Such were the principal conclusions as to the action of carriages upon roads contained in that memoir, which, when submitted to the judgment of the Academy of Sciences, had obtained the approbation of that illustrious Society, upon the report of a committee composed of M. Arago, Poncelet, and Coriolis, reporter. That work necessarily attracted all the attention of the administration of roads and bridges, as well as that of the committee of the Chamber of Deputies. The discussion, therefore, of the report of that committee, was adjourned to allow time to repeat and verify the results, and the conclusions announced.

"To arrive at this verification, the Minister of Public Works asked of his colleague, the Minister of War, that the author of the experiments should be attached to his department, for the special purpose of executing such others as should be judged necessary, according to a programme which had been requested from him, and a special committee of engineers of roads and bridges was charged with examining the successive results of the experiments.

"The experiments commenced in the month of March, 1839; their principal end being to discover the influence of the loads, of the breadth of the tires of the wheels, of the diameter, of the velocity, and of the springs, regard being had to the destructive effects produced upon gravel roads, the village of Courbevoie, (whence depart many solid macadamized roads, made of a siliceous gravel from the basin of the Seine, having all a thickness of 12 to 14 inches, at least, and having been put in a good state of repair,) was selected as a central point for the experiments. The general system of experimenting adopted was the following: The carriages, whose injurious effects were to be compared, were drawn over portions of the same road, taken at the beginning in the same state. Each of them had its particular track, over which it ran, going and returning constantly upon the same route, in order to accumulate and multiply the injury to the road. When the weather was too dry, the tracks were watered, in order to maintain them at the same relative degree of moisture. Each day the committee noted the number of passages executed by the carriages, and took care, in each series, to regulate this number, so as to make the same weight, including the carriages, pass over each of the tracks.

"When, after the transportation of the same weight upon the tracks to be compared, (each of which was always more than one hundred

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ficiently increased to give approximate results, the intensity of the force of traction of the carriages upon each track, was measured with very accurate dynamometers, and by the comparison of the different intensities observed with each other, and with that of the traction upon the untouched road, the absolute and relative increase of the traction corresponding to the injury produced, could be appreciated. These trials were repeated many times, and when it was at last judged that the injuries were sufficiently advanced to allow a conclusion to be deduced, the experiments on the traction were repeated for the last time; the state of the different tracks was noticed, and transversal sections of the ruts were drawn, in order to compare them with the primitive state of the road.

To these three means of comparison, there was afterwards added the sum of the quantities of materials employed in the repair of the road, after the removal of the mud and the dust, which gave nearly the empty space formed by the ruts, or the amount of the materials of the road ground up and separated. Thus, the committee had four methods of observation for comparison, in order to appreciate the destructive effect produced by the carriages—the account of the state of the ruts—the drawings of the transversal sections—the measurement of the intensity of the force of traction—and the amount of the materials employed in the repair. The results of these four methods have always presented a satisfactory agreement worthy of inspiring confidence in the conclusions which have been deduced from them.

"In order to determine the part which each one of the elements in this complicated question played, care was taken to separate it from the others. Thus, when the committee wished to compare the effects of different breadths of the wheels, they employed carriages exactly alike as respects the diameter, and all other circumstances except the breadth of the wheels. In the same way they determined separately the influence of the diameter of the velocity, and of the springs.

"Each of the series of experiments required not less than 20 or 25 consecutive days, and it was not until the end of the year 1839, that the results could be discussed. The principal experiments, and the conclusions which their author has deduced from them, are the following:

"Three wagons, mounted each upon four wheels of the same diameter, but with tires whose breadths were 6.9, 4.5, and 2.4 inches, respectively, were loaded proportionally to the breadths, in the ratio of 550 pounds for one inch. After the passage of about 8000 tons over each of the tracks, it was found that the track of the carriage with the largest tires was the most injured, while that of the carriage with tires 4.5 inches broad, was also seen to be more affected than that of the carriage with tires of 2.4 inches in breadth. Hence, it was concluded that, 'when the loads are proportional to the breadth of the wheels, the carriages with the broadest wheels, cause the most injury to the road.'

"Another series of experiments, executed with the same carriages, loaded with *equal* weights, including the carriages themselves, showed

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2.4 inches, do more harm to macadamized roads, than those with large tires, still there is little difference between the injuries caused by those with tires of 4.5 inches, and of 6.9 inches in breadth. This has confirmed the opinion announced in 1838, that there is not any remarkable advantage for the preservation of roads, in employing wheels more than 4.7 inches broad.

"The same wagons mounted upon wheels having a common breadth of 4.5 ins., and of the different diameters 2 ft. 10 ins.—3 ft. 11 ins.—6 ft. 8 ins., and loaded each with the same weight, 10,846 pounds, were drawn over three tracks upon the same road. After the transport of 9,741 tons, it was found that the wagon with the small wheels of 2 ft. 10 ins. in diameter, had produced the most considerable injuries, and that the wagon whose wheels were 6 ft. 8 ins., had only occasioned a trifling rubbing. Hence, came this conclusion, 'that wheels of a small diameter by the effect of separation of the particles of the road *(désagrégation)*, which they produce, do more harm than wheels of a great diameter.'

"Two post wagons exactly alike, and hung upon eight springs, were loaded, first with 13,200 lbs., and afterwards with 11,500 lbs. only. One of them whose springs had been wedged up, was drawn at a walk: the other, whose springs remained free, was conducted at a trot with the velocity of 8¾ miles per hour. After the transportation of about 4,534 tons upon each of the tracks of these wagons, it was found that the one ran over by the wagon on springs, was a little less injured than that of the wagon without springs, which went at a walk. Hence, came the conclusion, 'that carriages with springs going at a trot, can bear equal loads to those of carriages without springs, proceeding at a walk, without occasioning greater injury to a macadamized road than the latter.' The results of the experiments, also, having been the same from the commencement, when the road was in a good state, to the end, when the tracks had become very bad, the foregoing conclusion can be applied to all cases."

[This experiment is, perhaps, the most interesting and important of all which M. Morin made, because it is extremely difficult to determine *á priori*, the extent of the influence of springs, and we have hitherto had very few data by which we could form a judgment on this point. It will not be difficult now to find an approximate value for this influence. Let α represent the ratio of the force required to draw a carriage with springs, to that necessary to move at the same speed, the same carriage without springs. Then, if we suppose the speed with which the wagon, whose springs were wedged up in the foregoing experiment, proceeded, to have been 3¾ miles per hour, that part of its force of traction represented by $\frac{F'''}{\frac{1}{2}d}$ (eq. 8) was

$$\frac{15.H.(P-m.b^2.h).h}{4 \ldots . fh.d.m.b^{1-n}},$$

and when mounted on springs, and going at the rate of 8¾ miles per

hour, its force of traction $\frac{F_1'''}{\frac{1}{2}d}$ would, consequently, be,

$$\frac{35}{4} \cdot \frac{4}{15} \cdot \frac{15}{4} \cdot \frac{H.(P - m.b.^2 h).h.}{fh.\, d.\, m.b^{1-n}} X.$$

But since, according to the result of the experiment, $I = I'$, or

$$M.\left(fP + \frac{F'''}{\frac{1}{2}d}\right) = M.\left(fP + \frac{F_1'''}{\frac{1}{2}d}\right)$$

we must have $F''' = F_1'''$, and by substituting the values of these quantities just found, and reducing, it will appear that x is equal to $\frac{15}{35}$, or $\frac{3}{7}$. This, however, only represents the influence of springs in reducing the amount of F'''. To determine the entire effect upon the whole friction, we must observe that F'' is the only remaining part that is affected by the elasticity of the carriage, and that upon iron rails, F''' may be considered as vanishing, so that we there have $F = F' + F''$. Let us, also, suppose that these two quantities F' and F'', are equal to each other in this case, and further, that F', F'' and F''', upon a macadamized road, are also equal to each other. Now, it was found by M. Pambour, (Treatise on Locomotives, ch. iii, sec. 8,) that upon railroads $x = \frac{97}{100}$, whence it follows, that if F represent the friction of a railway carriage without springs, $\frac{97}{100}F = F' + \frac{94}{100}F''$, represents the friction with springs, and that $\frac{94}{100}$ is the factor by which F'' must be multiplied to show the effect of the use of springs. We shall find, therefore, that the resistance with springs in the case of macadamized roads, which we are especially considering, will be equal to Fy, or $F' + \frac{94}{100}F'' + \frac{3}{7}\frac{F'''}{\frac{1}{2}d}$, whence $y = \frac{79}{100}$, and, therefore, by the addition of springs, the friction, or force of traction, necessary to draw a given load, is reduced to 79 per cent. of what it would have been without them. The suppositions which have been made to arrive at this conclusion, are, in some respects, arbitrary, although they are scarcely unnatural, but, from a more general consideration of this question, it appears probable that the value of y is never greater than $\frac{1}{2}$, and it may, in practice, be always estimated as exceeding $\frac{2}{3}$. If it should amount, in any case, to this last quantity, the use of springs would allow the load to be increased one-third, whence it may be seen of what importance a complete investigation of the most effectual mode of applying, and fashioning springs, would be to the machinist, and the engineer.]

"A final series of experiments executed in 1839, has had as its object, to ascertain the influence of the division of loads upon the injury. A wagon with four wheels, each 6.5 inches in breadth, and weighing 17,457 lbs., or about 650 lbs. on an inch of the breadth of the wheels —a cart with two wheels 6.5 inches broad, weighing 11,000 lbs., or 846 lbs., on an inch of the breadth—and eight smaller wagons with tires 2.4 inches broad, weighing each 3,960 lbs., or about 412 lbs. per inch of the breadth of the sustaining surface, and going in a train, one exactly behind the other, were drawn upon three tracks, taken in the same condition at the outset, and kept constantly wet and muddy.

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After the transportation of 6,862 tons, it was evident that the four wagons drawn together, had caused much less injury than the other vehicles, and that the large wagon had done less harm than the cart, whose ruts had become so bad that it was almost impossible to draw it over the road.

"Hence, resulted the following conclusions. I. The division of loads upon many axletrees, or vehicles, is essentially favorable to the preservation of the roads. II. The wagons with tires 2.4 inches in breadth, going in trains, do less harm to the roads than large wagons and carts, carrying loads hitherto admitted. III. The load of 11,000 lbs. for a cart, and that of 17,457 lbs. for a four-wheeled waggon, (which amounts to about 10,406 lbs. on the hind-axletree) are so great as to occasion very remarkable injuries to the roads, and there is good reason to lay it down as a rule, that the load of carts, and that upon the hind-axletree of wagons, ought never to exceed much 8,800 lbs.

"Such were the most remarkable and important results of the experiments executed in 1839, by the order of the administration." Besides these experiments, of which a full account has here been given, to show the admirable manner in which they were conducted. another series was commenced in April, 1841, and continued until December, in the same year. As this series, however, was merely corroborative of those already described, and elicited no facts, or general laws, but what can be drawn from the others, it would be useless to translate more of M. Teste's report.

The experimental data which M. Morin has obtained, and, perhaps, the theoretical conclusions, which have been sketched in the foregoing pages, may do something to clear up, not only the question of the deterioration of roads, but the still more difficult problem of the laws of friction. So remarkable, and, apparently, irreconcilable, have been the variances between theory and experience, with regard to these laws, that mathematicians seem to have given up their investigation in despair, and Mr. Whewell has gone so far as to assert, that friction depends upon a distinct quality of matter, not yet discovered, and that it is vain to attempt to derive it from any of those common properties, with which we have hitherto had to do. Perhaps there is no good reason for so broad an assertion; perhaps more satisfactory results might have been obtained, by viewing the subject in a different light. It would, indeed, be idle to suppose, that the formulas, which have been given in this article, contain all that is necessary for a complete solution, or that they satisfy all the conditions of this intricate question. To do this would require a more subtle and careful analysis, than that here attempted; but the general method which has been employed, and the agreement of the equations, with the results of experiments, may not be unworthy of notice.

W.

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Architecture.

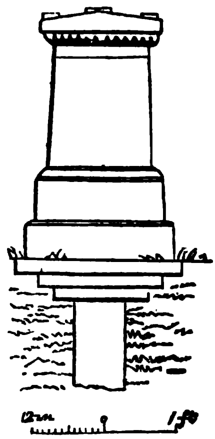
The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

(Continued from page 187.)

Sepulchral monuments, whether mausoleums (which is a term only applied to the most sumptuous description of tombs), square tombs, ledger-stones with inscriptions, sarcophagi, pedestals, vases, urns, columns, obelisks, pillars, crosses, &c., to have the appearance of security and permanence, ought to exhibit two features; they ought to be perfectly erect, or perpendicular, and they ought to rise from an architectural base. These features it is easy to exhibit when the monument is newly put up, but to continue them, even for a year, it is necessary to have a foundation of masonry under ground, as well as a basement above it; and, in order that this foundation may be permanently secure, it must be as deep as the adjoining grave, or graves. In the case of vaults and brick graves, this secure foundation is furnished by the structure itself; but in the case of common earth graves, a foundation requires to be built up, and the problem is how to effect this in a manner at once secure and economical. In most cemeteries and churchyards, and even in Père la Chaise, and Kensal Green, the greater part of the monuments have no other foundation than the moved soil, and only comparatively few are placed on the firm soil. The consequence of this is, that, in two or three years after the monuments are put up, they are found leaning to one side; or, if they are composed of several pieces, they are seen with joints rent, and conveying ideas the very reverse of permanence. Our remedy for the evil, is, two brick, or stone, piers at the head of each grave, carried up from the bottom, and from 9 in. to 2 ft. square, according to the depth. The two piers should be brought up at the same time, and tied together by building in pieces of iron hoop; and, when within a short distance of the surface, they should be joined by a semi-circular arch, or carried up to the surface, and connected by a lintel, which may be the visible base of the head-stone. Where a pedestal ornament of any kind, not more than 18 ins. on the side, was to be put up, one pillar 18 ins. square might suffice; or, when there was no danger of the ground being moved, even a 9-inch pier, as in fig. 5, would keep the pedestal from sinking. Where two graves

Fig. 5.



were built end to end, or side by side, three pillars would serve for both graves: and where four graves were to be made side by side, and end to end, three pillars would suffice; or, in effect, two pillars, as shown in fig. 6, the two half-pillars, at *a* and *b* not occupied, being charged by the builder to the cemetery, which would have a right to sell them to those who made adjoining interments. These pillars may be built in a few hours, by having beforehand portions of them prepared with brick and cement, in the manner familiar to every builder; or, in stone or slate countries, underground props of these materials might be formed; nor do we see any objection to cast-iron underground props. Where permanent endurance was the main object, we would not use cast-iron monuments; as it is next to impossible to prevent the rust from appearing through the paint, and scaling off so as to destroy, first the inscription, and next the body of the monument. In some of the London cemeteries, temporary labels of wood, having on them the number of the grave, or of the interment, and sometimes the name of the party interred, are used; and where economy is an object, and durability to the extent of a generation considered sufficient, we do not see any objection to the use of cast-iron tallies, such as fig. 7; their lower extremities being so fixed to a piece of wood, as to prevent them from being pulled out, while a circular disk, resting on two plain tiles, or bricks, will prevent them from sinking.

Fig. 6.

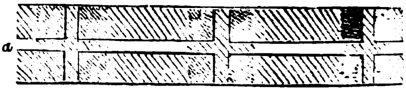
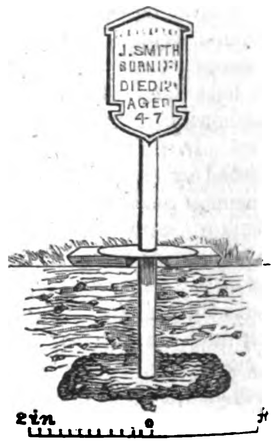
a  b

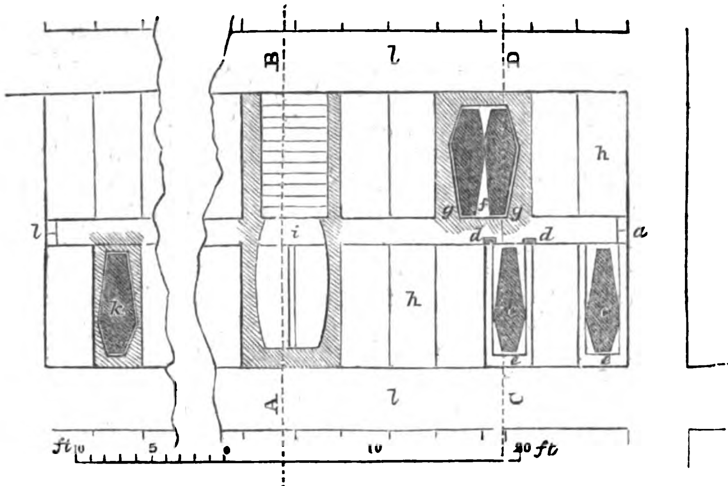
Fig. 7.



It is in order to supply room for head monuments that we have reserved a space of 2 feet in width between each double row of graves, as shown in the ground plan, fig. 8. In this figure, *a*, *b*, is the space between the two lines of graves, commencing and ending with a number-stone: *c*, *c*, are common graves with coffins, with piers for head-stones at *d*, *d*, and spaces for foot-stones, a foot in width, at *e*, *e*; *f*, is a brick grave with two coffins inserted, the head-stone to be placed between *g*, *g*, and *d*; *h*, *h*, are spaces left for common graves, brick graves, or, by occupying four divisions, for vaults: *i*, a vault for two coffins in width, occupying four divisions; *k*, a vault for one coffin in width, occupying one division; *l*, *l*, the green alleys between the double rows of grave beds, or panels.

When it is in contemplation to have a double line of brick graves, or to fill up a cemetery regularly, without allowing a choice to the purchasers, as in the cemeteries of the Jews, then a foundation wall 2 ft. in width, might be regularly carried up along the middle space, between the lines of graves, from one end of the line to the other.

Fig. 8.

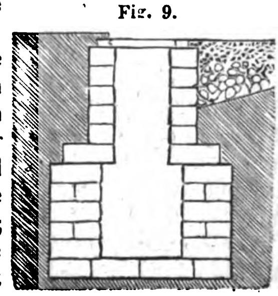


Cenotaphs, as every one knows, are monuments put up to the memory of persons who are interred somewhere else. They commonly consist of tablets with inscriptions, medallions, busts, basso-relievos, or other sculptural objects, and are very fit ornaments for affixing to walls under cover, or protected by architectural projections, such as those furnished by a chapel, a cemetery veranda, a boundary wall, or a structure erected on purpose, as is not unfrequent in the French and German cemeteries.

Walls, when used as the boundary of a cemetery, and built of brick, may be carried up hollow, which will be a considerable saving of material, and render all piers unnecessary, unless for effect, or, in the case of cemeteries laid out in imaginary squares, the piers which are to contain the stones having the letters and numbers.

The *main conveying-drains* of a cemetery, if built of brick, should be barrel-shaped, in the usual manner; but, if of stone, the bottom should be laid with flag-stone, and the same description of stone should be used for the covering. *Main collecting-drains* may be formed by semi-cylindrical tiles placed on flat tiles in the bottom, and small stones placed over them to within a foot, or less, of the surface of the ground. *Surface collecting-drains* may be 20 inches deep, formed like the last, with tiles at the bottom, and carried up to the surface with small gravel, finishing with coarse sand; and, when these drains are in the green alleys, grass may be sown over them. When at the sides of the gravel walks, or roads, they ought to communicate with surface gratings at regular distances; and immediately under each grating, there ought to be a pit 1 ft. square, and 2 feet

Fig. 9.



deep to retain the sand carried in by the water, (fig. 9,) this sand being taken out once a year. Where the roads and walks are laid with asphalte, gratings of this kind will be more necessary than when they are made of gravel, as a certain proportion of the water always sinks through the latter material, but none through the former.

The *furniture*, or tools, implements, and temporary structures, of large and complete cemeteries, consists of picks, spades, shovels, levers, rakes, scrapers, brooms; a rope and pulley, or block and tackle, to be used with a triangle; planks, ladders, grave-boards, dumcrafts, grave-platforms, grave-boxes, grave-moulds, wheelbarrows, buckets for raising soil, a frame for supporting canvas, or a tarpaulin over a grave while being dug during rain; and a temporary structure, consisting of a floor of boards, or wooden grating, with three sides, and a roof of canvas, rendered waterproof by paint, for the protection of the clergyman while reading the service at the grave; with another structure, of a larger size, for sheltering both the clergymen and the mourners.

The *grave-box* consists of a bottom and sides, the latter readily separating from the former; and its use is to hold the soil dug out of the grave, till the grave is ready to have the soil returned to it. From one to four boxes are required for a grave, according to its dimensions. Their use is two-fold: to preserve the soil from mixing with the grass, from which it is difficult afterwards to separate it so entirely as not to leave a quantity of it entangled among its leaves; and to return the earth in the most rapid manner to the grave. The box, before receiving the earth from the grave, is placed alongside, and raised up in a sloping position; the earth is thrown into it; and as soon as the coffin is lowered, the grave-diggers loosen and take out the side of the box next the grave, when the soil immediately begins to drop out, while, by raising the other side of the box, the whole is returned to the grave, and not a particle of earth is to be seen on the surface of the grass. This box was first used by Mr. Lamb, an undertaker in Leith, and is now in general use in the burial-grounds about Edinburgh. There ought to be a number of such boxes for every cemetery; and it would be an improvement to place them on low wheels, say those on the side which is to be next the grave of 6 inches in diameter, and those on the opposite side of double that height. This, while it would save the trouble of propping up the boxes, would also enable the grave-diggers to wheel them away, one after another, as fast as they were filled, and, when the grave was completed, to leave it quite free on every side, for the approach of mourners, who would in this case walk on the turf, instead of walking on loose earth, or planks. This result is sometimes obtained by throwing all the excavated soil into wheelbarrows, and removing these to a short distance, there to stand till the coffin is deposited. Either of these modes is much better than the common one of throwing up the soil on each side of the grave, and obliging the coffin-bearers to clamber over it. As the grave-boxes are readily taken to pieces, they can be stowed away, in sheds, or tool-houses, in little space.

A *clergyman's shelter* is unnecessary where a tarpaulin, or a movable shed, is used over the grave; but, where this is not the case,

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lighter, of wooden grating, raised one or two steps above the general surface, in order to give the reader of the service a more commanding position. To this floor three sides, each consisting of a frame of canvas, are readily fixed by means of studs in the lower rails of the sides, dropping into holes in the framework of the bottom; and they are as readily connected together by hooks dropping into eyes. The roof-piece, which ought to be raised a little in the middle to throw off the rain, can readily be dropped on four iron bolts, fixed in the upper ends of the styles of the sides. The whole may be painted black; and, when not in use, it should be taken to pieces, and kept in a dry, airy situation. A tent, or movable structure, to cover, not only the clergymen, but the mourners assembled, either during rainy weather, or hot sunshine, might be formed without difficulty, and at no great expense. The framework might be light iron rods; and the canvas might be so arranged as to be drawn up and let down, like the awnings to tulip beds, or the outside gauze shades to hot-houses.

Mechanics and Chemistry.

Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.

(Continued from Page 197.)

Section II.

Amongst the great variety of work denominated green-sand moulding, much and varied contrivance is displayed in the structure of the moulds. In particular, the management of cores is a matter of very considerable importance, and the malformation of them is a prolific source of failure in the production of sound castings.

Cores are especially useful for forming vacancies in castings. Their forms may be long, and proportionally small in diameter, or winding and otherwise intricate; and seeing that they are necessarily surrounded by the iron when cast, they ought to have, as much as may be, the qualities of firmness of substance, and openness of pores. Cores, as has already been stated in the first paper, are commonly composed of rock sand, and sea sand. The former, having a proportion of clay in its composition to which it owes its powerful cohesiveness, when dried, serves very well as a material for short cores that rest in the green sand at both ends, as open communication with it is thus afforded for the free escape of the air in the interstices of the cores. But when rock sand is used for cores of considerable length, (which, of course, are surrounded on all sides by the iron, except the small imbedded portions at the extremities, by which alone the air can escape,) it requires to be moderated by the admixture of free sand as a counteractant to the clay. The clay communicates the necessary cohesiveness to the material of the core: the sand, on the contrary, loose and open, renders it less binding, and more porous.

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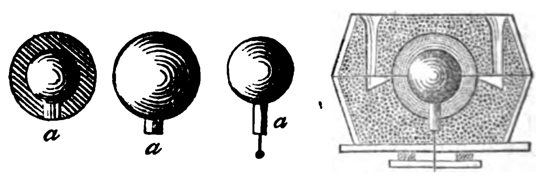
Free sand alone is also employed in the construction of confined cores, that they may afterwards be easily extracted, as the sand has naturally no power of cohesion. Wanting cohesiveness, it must be tempered to a proper consistency by the addition of clay and water, yest, or the refuse of the pease-meal, used for light, flat moulding purposes. In the use of the last material, it must be accurately proportioned to the sand with which it is mixed. The clay-water is, in ordinary cases, made use of as a cement, and the yest only in very particular circumstances. For large compact masses of core, the common green sand may be used, as illustrated in both examples, given in our last communication.

The longer cores are stiffened by iron wires, and small rods which are bent, if necessary, to the form of the cores. These rods are enveloped in the core in the progress of its formation, and are afterwards extracted from the casting. The cores of considerable length are pierced longitudinally by wires for the escape of the air; or, in cases in which this is impracticable on account of bends, or angles in the core, a piece of string is laid in the sand, alongside the stiffening wires, which is afterwards drawn out when the core is dry, leaving its perforation behind it.

With all these precautions for securing the strength of cores, and for the all-important purpose of letting off the air, blown holes do occur at times in castings, formed by the air thrown off the cores into the iron.

When the bearings of cores at the extremities are considered unfit for steadying them, they are further sustained by steeples stuck into the sand at several places in their length. These are simply nails with broad, flat heads, and several of them being set into the sand, and projecting above it just as much as the thickness of metal, the core is placed upon them, and sustained steadily in its place; the steeples are, of course, buried in the casting, and the points of them projecting outside, are chipped off in the course of dressing it. Chaplets* are also used to bear up cores having plane surfaces.

Fig. 1. Fig. 2. Fig. 3. Fig. 4.



An excellent example of the use of free-sand cores is found in the construction of bomb-shell mouldings. The form of a bomb-shell, it may be stated, is simply a hollow sphere of cast-iron, having one small round hole as a passage to the interior, termed the fuse-hole, as in the annexed sectional view, (fig. 1,) in which *a* is the fuse-hole. The pattern of the shell is a plain globe, (fig. 2,) of the same external diameter as itself, having a core print, *a*, upon it, answering to the fuse-hole, and of the same diameter. Fig. 3, represents the core, of

* In the last article, by a slight overlook, these objects are named steeples.

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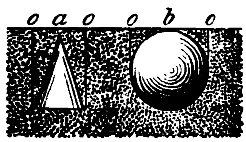
in a box which opens in two semispherical parts, to allow the core to be extracted. A piece of double-twisted wire is enveloped in the core, projecting at the neck with a loop at the outer end. By this wire the core is to be held down. Fig. 4, is a section of the moulding-box and the moulding, showing the core in its situation, and the applications for holding it there by means of the wire, which passes through the bottom of the moulding, and is locked on the under side. Two gates are also represented, by which the metal is poured.

It is evident, then, that when the casting is formed, the fuse-hole is the only exit for the core sand in the interior. The material of the core, ought, therefore, to be easily friable, as it can be broken down only by external blows. Accordingly, it is formed of free sand, so tempered with clay-water, or other binding principle, as to acquire just such a tenacity as will enable it to bear the action of the metal. The fuse-hole core is made of rock sand to enable it to bear the weight of the body of the core, and to withstand the strains to which it may be subjected. The surfaces of the core, and the exterior moulding, are washed with a mixture of blackening and water, to communicate smooth interior and exterior surfaces to the shell. A pricker is sent into the heart of the core through the neck, forming, by this means, a passage for the escape of the air confined throughout its substance.

Our next examples are intended to illustrate, generally, the manner of constructing patterns, in an exigency which frequently occurs, namely, when certain portions of a pattern enveloped in the sand, project horizontally beyond other parts which are above them. Were the pattern, in such circumstances, to be formed in one piece, it obviously could not be withdrawn from the sand without breaking up the moulding at the parts referred to. This idea may be explained by the annexed figures; *a*, *b*, fig. 5, being respectively a cone and a sphere. Were these objects buried in the sand, as shown in the fig., and then drawn out, the base of the cone would describe the space included in the vertical lines, *o*, *o*, and would, also, of course, remove the overlying sand. A similar result would ensue with the sphere. The lower part of the mould of the sphere would be left as it is, while the upper part between the lines, *o*, *o*, would be destroyed.

Fig. 5.



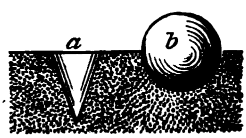


Fig. 6.

The simple remedy for these cases would be to invert the position of *a*, as shown in fig. 6, and to mould the sphere, *b*, so as to have its largest horizontal diameter at the surface of the sand. While the under half could thus be moulded in the under box, the upper half would be rammed up in the upper box. As in these, so in all other instances, patterns, or parts of patterns, to be capable of being moulded in sand, must, in their general outline, taper from the surface of the sand downward. For this reason, such parts of the surface of a

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are never made truly so. A slight tapering inclination is given them, that they may leave the sand the more readily.

A variety of other peculiar circumstances, however, frequently occurs, which require special methods of management. For example, a common sheave requires a particular, and an elegant process, to execute the moulding of it. Fig. 7, is a diametrical section of one. The circumference, it will be observed, is grooved out semi-circularly at *a*, *a*, and a hole, *o*, is made through the centre. The object is now to mould the pattern in such a manner as that the portion of sand forming the groove, *a*, *a*, may be left in its place when the pattern is drawn out. The pattern, fig. 8, must be formed in two halves, separated by a plane, *a*, *a*, passing through the centre of the groove. These halves are prevented from shifting by pins, *n*, *n*, or this may also be effected by a button on the centre of the one, fitting a recess in the other, as in the figure. There are also prints at *o*, *o*, for supporting the core.

Fig. 7.

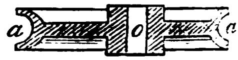


Fig. 8.

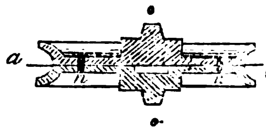
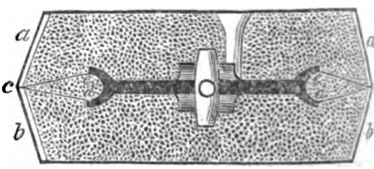


Fig. 9, represents, in section, the moulding of the pulley; *a*, *a*, and *b*, *b*, are the boxes. The pattern is first bedded in the lower box, and a parting, *c*, *d*, formed from the under rim to the edge of the box. The ring of sand, *c*, *d*, *e*, is, in the next place, rammed about the pattern, filling the groove, and its upper parting surface, *c*, *e*, is brought from the upper rim. Again, the upper box is placed on the other, and also filled.

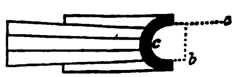
Fig. 9.



The ramming being now completed, and the gate-pin set, the box, *a*, *a*, is lifted off, carrying with it the impression of the upper side of the pattern. The upper half of the pattern being free, is lifted away, and the box, *a*, *a*, replaced. The whole is now inverted, and the box, *b*, *b*, is lifted off, thus permitting the remaining part of the pattern to be removed, which being done, and the moulding blackened and smoothed, and the core, *o*, set in, the box is replaced, and the two are finally reinverted. It will be observed, that the annular core, *c*, *d*, *e*, is never lifted from its situation during the process, and when the two boxes are linked together, it is wedged in on every side, and thus all possibility of shifting is removed.

Where there may not be facilities for turning the patterns of pulleys of large diameter, the grooves are cored out in the moulding. For this purpose, a core-print, running round the pattern, is provided in the making, as sketched in fig. 10, which is a section of the rim of a wheel supposed to be made with arms. The print is indicated by the dotted lines, and a core of the sectional

Fig. 10.



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form, *a, b, c,* is constructed in a core-box for the purpose. As there are only two boxes for the moulding, the pattern is mostly imbedded in the under one, the parting being formed on a level with the core print at *a.* It is not necessary that the core be all one piece; it may, for convenience, be formed in several segments.

We shall now select a fluted stove-pipe, as an example of another variety of adaptation. Fig. 11, is a transverse sectional view of the pipe, which may be supposed to be about five inches diameter, six feet long, and three-sixteenths of an inch thick. It will be observed, that the core, or interior of the pipe, follows in form the exterior surface, the object being to make the pipe as light as possible, otherwise a round core might have served the purpose.

Fig. 11.

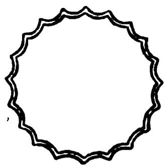


Fig. 12.

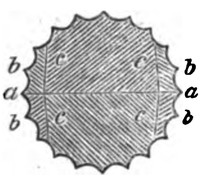
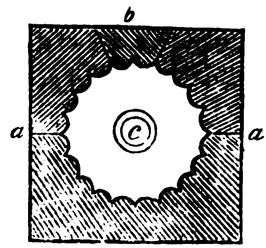


Fig. 13.



To determine, then, the method of casting this pipe:—It is to be noted, in the first place, as a general rule, that all cylindrical bodies of any considerable length, are moulded in two boxes, one half in each. Agreeably to this, the patterns are usually divided longitudinally in two halves. Referring to fig. 12, which is a cross section of the stove-pipe pattern, the line, *a, a,* represents the main division, which would suffice for a pattern having a plain exterior. For this column, however, deep as the flutes are, subdivisions are necessary to render the moulding of it practicable. For it is easily seen that the angles, *b, b, b, b,* immediately adjoining the parting, *a, a,* overhang the bottom of the hollows between *a* and *b,* and, therefore, if the patterns were drawn vertically out of the sand, they must break away the intervening portions of sand that occupy these hollows. Such parts of the pattern require to be removed laterally, and for this purpose, each half is made in three divisions, as represented at *c, c, c, c,* dovetailed to one another—allowing the smaller pieces to slide off the larger. Fig. 13, represents the core-box for the pipe. It is, like the pattern, parted in two at *a, a.* In the top of the upper half a loose piece, *b,* the length of the box, is provided, which being removed, the sand for the core may be introduced by the opening; *c,* is the core-bar, which runs the whole length for the purpose of stiffening the core.

The pattern having been moulded in the usual manner, one half in each box, so that the plane, *a, a,* fig. 12, coincides with the parting of the sand, the middle piece of each half is first drawn out, when the smaller pieces may next be removed laterally, to make way for the core.

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On this principle of construction, in similar circumstances, patterns are generally made. Fitting strips, for example, when applied to the vertical face of a pattern, below the surface of the moulding, are attached to it by sliding dovetails. Core prints are very often placed in such circumstances. In fig. 14, which is the pattern of a flanched plate, *a* and *b*, are two core prints, which, instead of being dovetailed to the pattern, are carried quite down to the plate, which is moulded in an inverted position; these continuations clear the way for the prints themselves, which would otherwise break the moulding. After the cores are introduced, these temporary vacancies are filled up with the aid of smooth strips of wood, and the figure of the moulding restored. In general, core prints, on vertical faces of patterns, are carried up to the parting surface with the view of making their own passage, which is afterwards closed over the core.

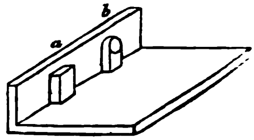

Fig. 14.

Take, for our next example, a paneled octagon column, or post. It presents a more complicated structure than the stove-pipe, and to render it workable in the sand, the panels are, each by itself, made separable from the body of the pattern, being attached to it by screw-nails, which are driven off the inside. The pattern is divided into two principal halves. When it is moulded, the panels, of which there are four to each half, are fixed on. When the parts of the box are separated, exposing each a half interior of the pattern, the screws are returned and withdrawn, thus leaving the frame of the pattern at liberty from the panels. It is next lifted out, and these being disengaged from the sand by tapping, are likewise taken out in order. In this way a complete external moulding of the column is formed. The core, constructed upon a stout bar, is next inserted, and the box closed upon it.

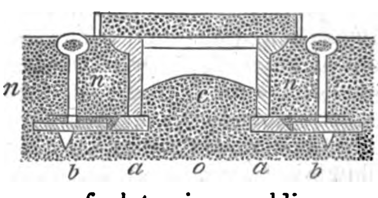

Fig. 15.

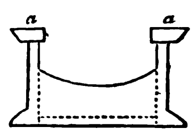

Fig. 16.

Of the use of plates in moulding, an example has already been given in our last paper in the account of the moulding of an engine sole-plate. A different application will now be described in relation to the moulding of a lathe-bed. Fig. 15, is an end view of the bed: *a*, *a*, are the upper sliding surfaces, overhanging the sides; these are connected and stiffened at several parts by deep flanches joining them. The surfaces, *a*, *a*, as they are the most important parts of the bed, are, according to the general rule, moulded undermost, the object being to secure a sound structure, at these parts, free from blown holes and impurities, which collect, more or less, towards the upper side of every casting. Fig. 16, is a section of the pattern and moulding.

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pattern. The first step is to bed the pattern in an inverted position, thoroughly on the floor, which is levelled and smoothed all about it. Plates, *b*, *b*, extending the whole length of the pattern, are sent along both sides of it, an inch or so apart, to support the sand exterior to the pattern. A series of small rods, either of wood or iron, is placed on each plate. These rods overhang it on the side next the pattern, from which, however, they must be at some distance. In this way, the rods form a projecting platform, by which the sand that would overhang the plate is sustained. If of wood, the rods are dipped in clay-water, that they may adhere to the sand. The moulding is now made up with sand, flush with the pattern within and without. The parting surface is formed, and covered in by the upper box in the usual manner, which, being lifted off, and the pattern having been loosened, it is drawn out, leaving the loose pieces, *a*, *a*, imbedded in the three masses of sand, *n*, *n*, *o*. The masses, *n*, *n*, resting on the plates, are raised and moved aside by handles which are cast upon the plates, and project upwards. The pieces, *a*, *a*, being thus relieved, are edged out from below the sand, *o*, and removed. *n*, *n*, are replaced as before, guided by conical projections from the plates, and the moulding is covered in by the upper box.

Plates are also employed in the moulds of bevel-wheel patterns for lifting the bodies of sand sunk between the arms. Frequently, too, in miscellaneous cases, where considerable depths of sand occur in the upper part of the mould, slips of wood are planted vertically in the masses, reaching upwards between the ribs of the upper box, their object being to bind the whole body of sand the more firmly together.

(To be continued.)

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Dynamometer for the Measuring of Steam, or Water, Power.

In your Journal for May, I find an article from the Edinburgh New Philosophical Journal, dated from Manchester, "On the method of registering the force actually transmitted through a Driving Belt; by Edward Lang, Esq., Professor of Civil Engineering, College, Manchester."

The method proposed is founded upon the extension, or stretch, of the belt, by the force communicated through it. That is, that the working side of the belt will be more extended than the slack side, and, consequently, the pulley on the machine will not revolve through so many inches, in a given time, as the drum that communicates the motion; or, in other words, suppose the working side of a belt may be extended one, two, or three, inches in an hundred, more than the slack side, it will, of course, lap round the driving drum, in that extended state; while the opposite side is received upon the driven pulley in the slack state, and will communicate so much less motion,

and as the difference between the motion communicated to the pulley, and that of the drum, will bear a certain proportion to the strain on the belt in each individual instance, the author says:—"We have only to contrive some method of registering this difference, in order to have a record of the total force transmitted by the belt." He then proceeds to a practical application of the principle, and proposes a plan for indicating the difference between the motion of the drums and the pulley, and also experiments with a particular belt, to ascertain what *force* a certain difference in these motions would indicate. He then says, "when the multiplier for one belt has been ascertained, that for any other belt may be approximately computed, if it be of the same material, by having regard to the relative weight of a foot of each," &c.

The reason of my calling your attention to this article, is, that the proposal of so imperfect and complicated a plan, shows the want of a good Dynamometer for this purpose, and that neither the writer of the article, a professor of civil engineering in the college of Manchester, nor the editor of the Philosophical Journal at Edinburgh, (though both might be supposed to be well informed on such matters,) were acquainted with a very simple and accurate instrument constructed for the purpose in this country, to which I am about to call your attention, as described in an article in the Monthly Chronicle, published in Boston, November, 1840.

"At the Mechanics' Fair in Boston, in September, 1839, an ingenious and valuable machine was exhibited, the purpose of which is to obtain an accurate measurement of the degree of power, exerted at any time, in the movement of machinery, while in regular operation. It is applicable alike to steam, or water, power, and is susceptible of being made of either large dimensions, for the measurement of the power of large water-wheels, or engines, or of smaller dimensions, applicable to the more exact measurement of the power exerted in the movement of light machinery. It is the invention of Samuel Batchelder, Esq., of Saco, the Agent of the York Cotton Factory. It is on a principle, which, we believe, is entirely novel, yet simple, and manifestly applicable to the accurate attainment of its object. In applying it to use, in any particular case, it is only necessary to place it in the line of communication, between the engine and machinery to be moved, by means of drum-belts, or gearing. When it is so placed, forming a line of connexion between the moving power, and the machinery to be moved, the degree of force exerted in overcoming the resistance to the motion of the machinery, at any given time, is accurately measured, by means of a steel-yard bar and weight. The position of the weight on the graduated bar, required for keeping this bar balanced in a horizontal position, indicates the measure, in pounds, of the power exerted at the time. There is connected with the machine an index, to show the number of revolutions of the drum connected with the water-wheel, or steam-engine, in a given time, by which, together with the weight, or resistance, to the motion, it will be readily shown how many pounds would be raised a foot high per

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exerted. The form of the machine is illustrated by the following drawings

Fig. 1.

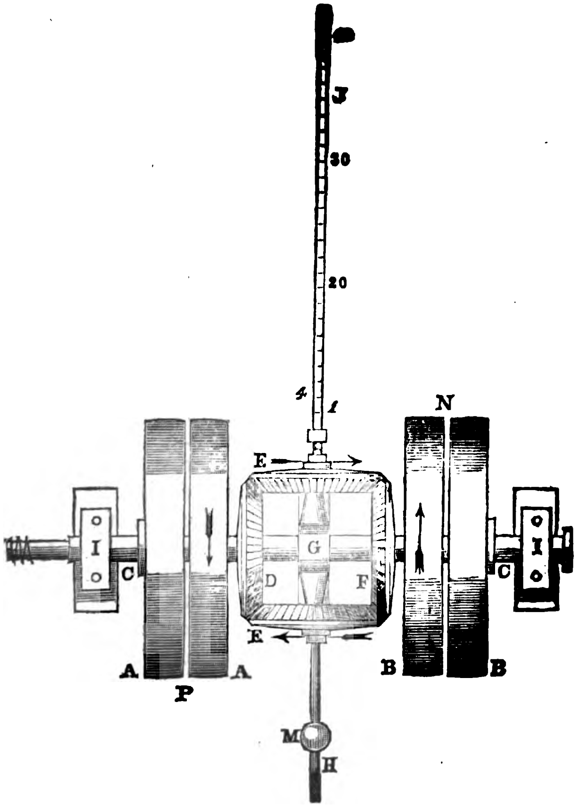
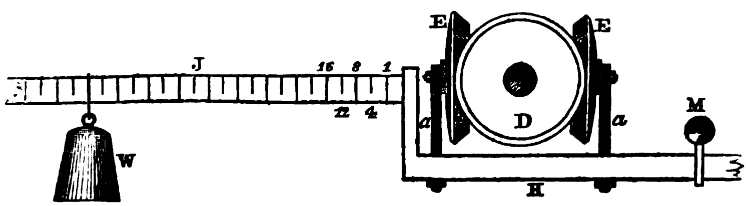


Fig. 2.



The cuts, figures 1 and 2, give a view of the dynamometer, in which AA, and BB, denote two pair of belt pullies, each pair consisting of a fast and loose pulley. The operation of the machine is to receive the motion, or power, from the drum, or prime mover, by a belt upon the pulley, A, and to transmit it to the machine, which is

the subject of experiment, by a belt on the pulley, B. The fast pulley, A, and the bevil wheel D are fast upon the shaft, CC, which revolves in the bearings, I I. The bevil wheel F, is connected with the pulley, B, by a tube, or hub, through which passes the shaft, CC, upon which this pulley and wheel are supported, the shaft revolving freely in the tube, or hub. In order to give motion to the pulley, B, a connexion must be formed between the bevil wheels, D and F; for this purpose they are geared together by the bevil wheels, EE, which run upon a cross shaft, through which the main shaft passes freely, at G. Now, it is evident, that if this cross shaft is not held in its place by some force, the motion of the bevil wheel, D, will only cause the shaft to move round and round upon the shaft, C, and the wheels, EE, rolling upon the wheel, F, without communicating to it, or to the pulley, B, any motion; but if the wheels, EE, and the shaft, G, are held in place, the motion of the pulley, A, will be communicated to the pulley, B, through the bevil wheels, and the force there applied to retain the shaft, G, and the wheels, EE, in place, will indicate the power transmitted through the dynamometer. This power is ascertained by means of a graduated beam, like that on a common balance, or steelyard, as represented by H J, attached to the shaft of the wheels, EE, as represented in fig. 2, by the straps, *a*, *a*.

The weight, M, fastened by a set screw, affords the means of balancing the lever horizontally, when the machine is at rest; and a weight, W, like that of the common balance, moved upon the graduated arm of the lever, will indicate the strain upon the belt. The number of pounds thus indicated, multiplied by the number of feet through which the belt moves per minute, will give the number of pounds raised one foot high per minute, according to the usual manner of estimating the power of steam engines, or other prime movers, allowing, as usual, 33,000 pounds raised one foot high per minute, to the horse power. A worm, on the end of the shaft, CC, is made to move an index, which shows the number of feet through which the belt, or the surface of the pulley, moves in a given time.

In graduating the arm of the balance, J, the division, marked 10, is at the same distance from the centre of the shaft, C, with the surface of the pullies, or equal to the radius of the pulley. The same additional distance is marked 20, and again the same 30. Now, if we suppose a power of 10 pounds applied to the pulley at P, it will balance the same weight on the opposite pulley at N; but it ought to be kept in mind that it will require a weight of 20 pounds at 10, to balance and keep in place the arm of the lever; for, as the pivot of the wheel, E, acts as a fulcrum, it must not only sustain the power exerted by the wheel, D, but the power communicated to the wheel, F, so that a counterbalance of 20 pounds must be used, to correspond with the numbers, 10, 20, 30, upon the graduated arm of the lever.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Steam Boilers.

Mr. Bakewell, of Cincinnati, replies to our article published in the July number of the Journal, (page 54) on the Strength of Cylindrical Boilers. Mr. B. misapprehends us; we do not, in our solution, assume any "parallelism in the action of the steam," as he supposes; but we admit that it acts, like other elastic fluids, perpendicularly to the inclosing surfaces—in this case the periphery of the cylinder. We have no objection to the new hypothesis which Mr. B. introduces, of a solid body below the line A, B, to which the semi-cylinder, A, B, D, is supposed to be attached, although we deem it unnecessary. The supposition, as he correctly states, does not alter the conditions of the problem. But then he errs greatly when he jumps to the conclusion, that "the operative force to produce rupture at B," would, by the received theory, be but one-half its value at D. Our equation—which is in accordance with the received theory—leads to no such incongruous result.

The general expression of the moment of the force, with reference to A, is,

$$\int \mathrm{F}x\frac{dx}{ds}ds+\int \mathrm{F}y\,\frac{dy}{ds}\,ds.$$

Now, if B be the point selected for the rupture, we have $x=\text{rad.}=\frac{\delta}{2}$, and must, accordingly, integrate from $x=o$, to $x=\frac{\delta}{2}$. By the operation we obtain,

$$\mathrm{F}\frac{\delta^2}{4}$$

for the moment of the force. The resistance of the metal is Pt; and the arm of the lever, by which it acts, is $\frac{\delta}{2}$, consequently, the moment of the resistance is here,

$$\mathrm{P}t\frac{\delta}{2};$$

which must be equal to the moment of the force; whence results,

$$\mathrm{F}=\frac{2\,\mathrm{P}t}{\delta},$$

as given by Mr. Latrobe. If Mr. Bakewell had read our former solution carefully, it would have spared him much trouble. E.

On a Self-acting Circular Dividing Engine; read before the Roy. Astron. Soc. Lond. June 9, 1843. By W. Simms, Esq.

The original graduation of a circle, notwithstanding the great improvements in the method invented by Mr. Troughton, is still attended

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with very great difficulties, requiring not only the greatest care, on the part of the operator, but tending to injure his health by the labors required in it, and thus not admitting of frequent repetition. The necessary cost of an instrument produced by such an amount of severe labor, is also another very serious objection. The author had long been of opinion, that to copy the divisions of a circle which had been graduated with extraordinary care, upon work of smaller dimensions, would, in general, be more satisfactory than original graduation. The latter process consists of several successive steps, in either, or all, of which a certain amount of error may escape detection, which, in general, may go far to balance one another, although there will be parts in almost every work where errors appear arising from an accumulation of those minute quantities.

The author had long since determined, as soon as he could obtain sufficient leisure, to construct an engine sufficiently large for the graduation of all circles, excepting those of the largest class, and the object of this paper is to lay before the Society, a brief notice of the successful termination of the work.

The engine, in general arrangement and construction, is similar to that made by Mr. Edward Troughton, in the author's possession, though there are several additions and peculiarities which are pointed out by him. The circle, or engine-plate, is of gun-metal, 46 inches in diameter, and was cast in one entire piece by Messrs. Maudslay and Field, teeth being ratched upon its edge. The centre of the engine-plate is so arranged that it can be entered by the axis of the instrument to be divided, and the work, by this means, brought down to bear upon the surface of the engine-plate, which arrangement prevents the necessity of separating the part intended to receive the divisions from its axis, &c.—a process both troublesome and dangerous.

Upon the surface, and not far from the edge of the engine-plate, are two sets of divisions to spaces of five minutes, one set being in silver, and the other strongly cut upon the gun-metal face. There are also as many teeth upon the edge, as there are divisions upon the face of the engine-plate, namely, 4320, and, consequently, one revolution of the endless screw moves through a space of five minutes. The silver ring was divided according to Troughton's method, with some slight variations. In this operation it seemed to the author the safer course to divide the circle completely, and then to use a single cutter for ratching the edge; and he believes that the teeth upon the edge have been cut as truly as the original divisions themselves.

Another very important arrangement is, that the engine is self-acting, and requires no personal exertion, or superintendence, nothing being necessary but the winding up of the machine, or rather the raising of a weight, which, by its descent, communicates motion to the dividing engine. The machinery is so arranged, that it can be used, or dispensed with, at pleasure, there being some cases in which a superintending hand is desirable.

The author then proceeds with a description of the machinery, as represented in the drawings accompanying his paper, and draws

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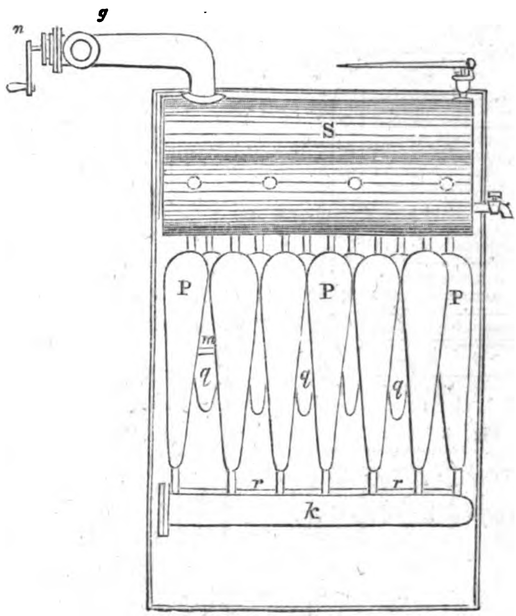
He concludes by observing, that as the machinery is simple, by no means expensive, can be made by an ordinary workman, is adapted to all the engines now in existence, which are moved by an endless screw, as it lessens the labor of the artist, and increases the accuracy of the graduated instrument, he trusts his communication will prove acceptable to all who are interested about such matters.

Lond. Edin. & Dub. Phil. Journ.

On the Steam Power of Mr. Henson's Flying Machine.

Fig. 1.



The difficulty of mechanical flying consists less in devising an apparatus capable of floating in, and being moved through the air in any given direction, than in freighting it with mechanical power sufficient to enable it to maintain its place through long distances against the constantly adverse influence of gravitation, and the frequently concurring opposition of the wind and weather. The means by which Mr. Henson hopes to overcome this difficulty, that is to say, the boiler by which he proposes to generate steam enough for any given length of flight, deserve, therefore, a little more consideration than they have as yet received at our hands. We, therefore, lay before our readers the accompanying engravings of the boiler, with the explanations furnished by Mr. Henson himself in his specification.—[Ed. *London Mech. Mag.*]

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Fig. 1, represents a side elevation, and fig. 3, a front elevation of the boiler; figs. 2 and 4 are top and bottom sectional views. S, is the body, or principal part, of the boiler, consisting of three cylinders, the steam from which passes off through the pipe, *g*, which is provided with a valve. The smaller cylindrical vessels, *t*, *t*, are joined by the pipes, *u*, (four of which are indicated by dotted circles in fig. 1.) The larger conical vessels, P, P, P, connect the pipe, *k*, *k*, and the principal cylinders of the boiler, in the manner shown in the figures. The smaller vessels, *q*, *q*, are connected to the principal cylinders, as also to the vessels, P, P, as shown at *m*, figs. 1 and 3. The furnace is divided into two compartments by the vessels, P, P, P, as seen in fig. 2. *r*, *r*, are the furnace-bars, resting on the pipe, *k*, *k*, so that the vessels, P and *q*, are subjected to the full power of the fire; *f*, *f*, is the place of exit for the smoke.

Fig. 2.

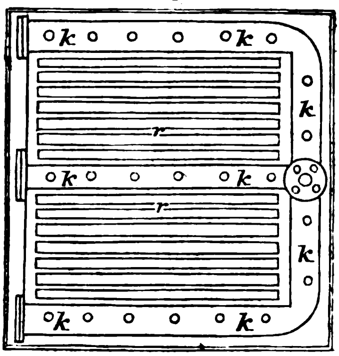


Fig. 3.

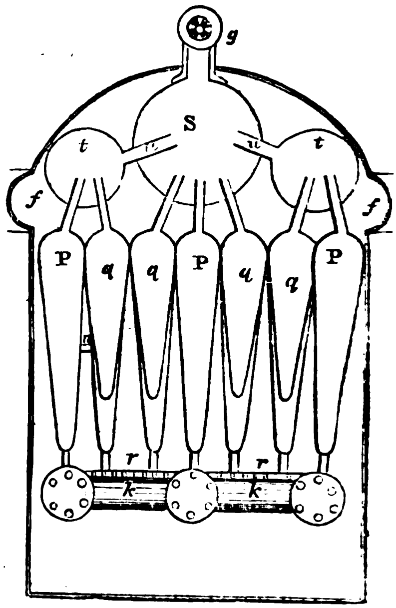
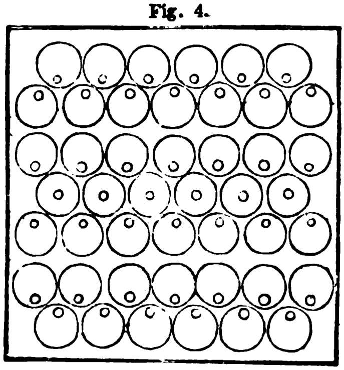


Fig. 4.



The vessels, S, *t*, P, and *q*, Mr. Henson proposes making of copper, and the joinings of brass, on account of the greater strength of copper when compared with iron, weight for weight, and also on account of its greater heat-conducting power.

The two induction and eduction valves of the engine, which are simply cocks varying little from the ordinary form, are to be worked by four eccentric wheels.

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On the Electricity evolved by the Friction of Water and Steam against other bodies. By MICHAEL FARADAY, ESQ.

The object of the experiments related in this paper, is to trace the source of the electricity which accompanies the issue of steam of high pressure, from the vessels in which it is contained. By means of a suitable apparatus, which the author describes and delineates, he found that electricity is never excited by the passage of pure steam, and is manifested only when water is at the same time present; and hence he concludes, that it is altogether the effect of the friction of globules of water against the sides of the opening, or against the substances opposed to its passage, as the water is rapidly moved onwards by the current of steam. Accordingly, it was found to be increased in quantity, by increasing the pressure, and impelling force of the steam. The immediate effect of this friction, was, in all cases, to render the steam, or water, positive, and the solids, of whatever nature they might be, negative. In certain circumstances, however, as when a wire is placed in the current of steam at some distance from the orifice whence it has issued, the solid exhibits the positive electricity already acquired by the steam, and of which it is then merely the recipient and the conductor. In like manner, the results may be greatly modified by the shape, the nature, and the temperature of the passages through which the steam is forced. Heat, by preventing the condensation of the steam into water, likewise prevents the evolution of electricity, which again speedily appears by cooling the passages, so as to restore the water which is necessary for the production of that effect. The phenomenon of the evolution of electricity in these circumstances, is dependent also on the quality of the fluid in motion, more especially in relation to its conducting power. Water will not excite electricity unless it be pure; the addition to it of any soluble salt or acid, even in minute quantity, is sufficient to destroy this property. The addition of oil of turpentine, on the other hand, occasions the development of electricity of an opposite kind to that which is excited by water; and this the author explains by the particles, or minute globules, of the water having each received a coating of oil, in the form of a thin film, so that the friction takes place only between that external film and the solids, along the surface of which the globules are carried. A similar, but a more permanent, effect is produced by the presence of olive oil, which is not, like oil of turpentine, subject to rapid dissipation. Similar results were obtained when a stream of compressed air was substituted for steam in these experiments. When moisture was present, the solid exhibited negative, and the stream of air positive electricity; but when the air was perfectly dry, no electricity of any kind was apparent. The author concludes with an account of some experiments in which dry powders of various kinds were placed in the current of air; the results differed according to the nature of the substances employed, and other circumstances.

Lond. Athenæum.

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The author, after briefly stating the results of his experimental inquiries, published on this subject in 1829, proceeded to describe two instances which had recently come under his notice, illustrative of the solvent action of certain terrestrial waters on lead, and of the danger of using this metal for conducting water in pipes, unless with a due regard to the circumstances which promote, or prevent, its corroding property. In one instance, the water of a spring, conveyed in a lead-pipe from a distance of three quarters of a mile, was found to act so powerfully on the lead, that in a short time the cistern in which the water was collected became covered with loose carbonate of lead, and the metal could easily be detected in the state of oxide dissolved in the water. In this case, the action was found to depend on the spring being of extraordinary purity, its total saline ingredients being only a 22,000th part. In the other instance, water conveyed half a mile in a lead pipe, was impregnated exactly in the same way, and with the very same phenomena—but with the additional circumstance, that, in consequence of the impregnation not having been detected in time, as in the previous case, the disease, *Colica pictonum*, broke out in the house supplied with the water. In this case, the water was by no means pure, as it was found to contain no less than a 4,500th part of saline matter. But there was scarcely any other salt present except muriates, which the author had ascertained in his former researches not to prevent the action of water on lead, unless present in much larger quantity.

He next proceeded to explain in what manner the action of the water was put an end to in both these cases. In similar instances, the only remedy formerly thought of was substitution of iron-pipes. In the former of the two cases which fell under his notice, the water was left at rest in the pipe for four months, till a firm crust of mixed carbonate and sulphate of lead had crystalized on the lead; after which no farther action took place. In the latter instance, the same end was attained by keeping the pipe full of a solution of phosphate of soda, consisting of 27,000th of the salt.

The author appended an analysis of the compound formed by the action of distilled water on lead. Guyton-Morveau and others considered it a hydrated oxide; the author himself, in 1829, thought it a neutral carbonate; and, in 1834, Captain Yorke first considered it a hydrated oxide, and eventually concluded from his analyses, that it is an irregular mixture of hydrated oxide and carbonate of lead. The author finds that the product is a hydrated oxide, when the action goes on without the access of carbonic acid; but that, when the action proceeds in the usual way, under exposure to the atmosphere, the product is a crystalline body, of which the primitive form seems to be the regular octahedron, and which is composed of two equivalents of neutral carbonate, united with one equivalent of hydrated oxide ($2\,PbOCO^2 + PbG$ Aq.)

He then stated the following to be the general conclusions to be

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1. Lead-pipes ought not to be used for the purpose of conveying water, at least where the distance is considerable, without a careful chemical examination of the water to be transmitted.

2. The risk of a dangerous impregnation with lead is greatest in the instance of the purest waters.

3. Water, which tarnishes polished lead, when left at rest upon it in a glass vessel for a few hours, cannot be safely transmitted through lead-pipes without certain precautions.

4. Water, which contains less than about an 8000th of salts in solution, cannot be safely conducted in lead-pipes, without certain precautions.

5. Even this proportion will prove insufficient to prevent corrosion, unless a considerable part of the saline matter consist of carbonates and sulphates, especially the former.

6. So large a proportion as a 4000th, probably even a considerably larger proportion, will be insufficient, if the salts in solution be in a great measure muriates.

7. In all cases, even though the composition of the water seems to bring it within the conditions of safety, now stated, an attentive examination should be made of the water, after it has been running for a few days through the pipes. For it is not improbable that other circumstances, besides those hitherto ascertained, may modify the preventive influence of the neutral salts.

8. When the water is judged to be of a kind which is likely to attack lead-pipes, or when it actually flows through them impregnated with lead, a remedy may be found either in leaving the pipes full of the water, and at rest for three or four months, or by substituting for the water a weak solution of phosphate of soda, in the proportion of about a 25,000th part.

Edin. New Phil. Journ.

English Patents.

Specification of a Patent granted to William Cotton, Esq., of Leytonstone, *for an improved Weighing Machine. Patent dated June* 13, 1842; *Specification enrolled August* 10, 1842.

Mr. Cotton, who is Governor of the Bank of England, has invented this machine for the purpose of weighing sovereigns, and separating the light ones from those of standard weight. It is so delicate, that it detects, with precision, a variation of a twelve thousand two hundred and fiftieth part of the weight of a sovereign. The coins are placed in a tube, or hopper, from whence they are carried on to a small platform, which is suspended over a delicately poised beam, to the other end of which is appended the standard mint weight. On setting the machine at work, a sovereign is placed on the platform, and if it is full weight, a small tongue advances, and strikes it off into a till appointed to receive it; but, if it is light, the platform

sinks, and brings it within the reach of another tongue, at a lower level, which advances at right angles to the former tongue, and pushes the coin into another till. Other coins succeed in rapid rotation, so that the machine can weigh, and sort 10,000 sovereigns in six hours, while an experienced teller, can, at the utmost, only weigh between 3,000 or 4,000 coins, by hand-scales, in the same time, and even then, the optic nerve, by incessant straining, becomes fatigued, and errors occur.

Lond. Mech. Mag.

Specification of a Patent granted to Samuel Dotchin, of Hoxton, *for improvements in paving, or covering and constructing roads, ways, and other surfaces. Sealed 8th October*, 1842.

These improvements consist in paving roads, &c., with blocks of wood, or other suitable material, of the peculiar form represented in fig. 1, which is a side view, and fig. 2, a plan of the block; the latter fig. being encompassed by a circle, to shew that it may be cut out of a circular block, or piece of timber. The improved block consists of six sides, and an upper and lower surface; the sides are all equal, but, instead of being formed perpendicular to the upper and lower surfaces, they incline alternately in opposite directions. The advantages to be derived from this form, are, that each block will be supported by three of the adjoining blocks, and will also support three, as shewn at fig. 3, which is a plan of part of a pavement; the spaces between the upper parts of the blocks are filled with asphalte, sand, &c.

Fig. 1.

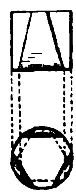
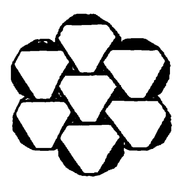


Fig. 2.

Fig. 3.



The patentee does not claim the use of blocks of wood, or other material, with six sides, generally, but only when the sides are caused to incline in opposite directions, as shewn in the drawing, in order that each block may support, and be supported, by the surrounding blocks. He claims, also, combining a series of blocks, of the figure above described, for paving, or covering, and making roads, ways, or other surfaces.—[Enrolled in the Enrolment Office, April, 1843.]

Ibid.

Abstract of a Patent granted to Charles Keene, of New Bond street, *for improvements in the manufacture of hose, socks, drawers, gloves, mitts, caps, comforters, and cuffs.* Patent dated December 15, 1842; Specification enrolled June 15, 1843.

Mr. Keene premises, that he has found that when fabrics into which threads of Indian rubber have been introduced, are cut up in lines parallel to these threads, the cloth is not apt to fray, or fringe, out. Applying this fact, he forms elastic bands for the wrists of gloves, by introducing threads of Indian rubber as weft, or warp. In either case he forms a band of sufficient width for the required wrist; be-

tween the threads of Indian rubber, he introduces one or two picks of wool, or cotton, &c., according to the fabric, but preferring wool. Immediately in contact with this band, there is woven a sufficiency of stuff, from which may be cut the glove, leaving the band at the top to become the wrist, so that the web may consist of as many breadths, or lengths, as may be convenient, taking care only, to have a band, into which has been woven the India rubber, to become the elastic wrist. The caoutchouc may be rendered elastic in the usual manner, either before it is woven, or afterward.

Another part of the invention has reference to the manner of cutting out, or forming, what he calls *overalls* for gloves, stockings, mitts, caps, drawers, &c., which are used to keep the gloves, &c., underneath, close to the body for warmth. They are to be cut from a web into which threads of India rubber have been introduced, either as warp, or weft, or from a fabric formed similar to that made by the warp lace machines, either diagonally, or longitudinally. The overalls, &c. &c., are to be cut in such a manner, that the threads of Indian rubber shall take a diagonal direction over the hand, when they will be found readily to yield to the form of the hand, &c.

The claims are: 1. To the application of elastic bands, made in warp machines, as above described.

2. The making of the fabric in manner above described, so that when the gloves, &c., are cut out, there shall be an elastic band for the wrist.

3. The mode above described, of making overall gloves, mitts, &c., so that the threads of Indian rubber shall always lie in a diagonal direction across the hand, &c., whether the fabric be made by the common warp, or by warp lace machines. Ibid.

Abstract of a Patent granted to William Henry Fox Talbot, Esq., of Laycock Abbey, *for improvements in coating, or covering, metals with other metals.* Patent dated November 25, 1842. Specification enrolled May 25, 1843.

The specification of Mr. Talbot's present patent discloses no new principle in the art of metallic precipitation; but it supplies some very useful improvements in its manipulative details.

1. To prepare metal articles for gilding, Mr. Talbot dips them in a weak solution of silver in hyposulphite of soda.

2. To prepare an article for either gilding, or silvering, he first cleans it well, then connects it to one of the wires of a voltaic battery, next plunges both poles into a vessel filled with some acid solution, which, decomposing the water, the hydrogen is given off by the article intended to be gilt, or silvered. After a little time the article is detached from the battery, and thrown into a solution of gold or silver, where it speedily acquires the required coating.

3. To gild metallic articles, he makes use of a mixed solution of gold, and any one of the baser metals, with the exception of mercury, which would separate the gold.

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4. He also uses for gilding, a solution of chloride of gold, mixed with a solution of boracic acid, the latter having the effect of greatly improving the color.

5. To remove the dark tint which metallic articles sometimes acquire when dipped in a solution of gold, they are immersed in a very weak solution of nitrate of mercury. Any mercury which may adhere, is afterwards removed by an acid, assisted by voltaic action.

And, 6. When, in silvering an article, the solution of silver ceases to impart any addition to the coating, (in consequence of the coating and the solution becoming of identical properties,) Mr. Talbot dips it into a different solution of silver, or into a solution of some other metal, after which he replaces it in the first solution, when it is found to act with the same energy as at first. The same method of alternate dipping is also applicable to solutions of gold. *Ibid.*

METEOROLOGICAL OBSERVATIONS FOR FEBRUARY, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	33°	26°	29.36	29.36	NW.	Moderate		Cloudy.	Cloudy.
	2	18	26	29.70	29.86	W.	Blustering		Clear.	Clear.
	3	20	33	30.10	30.10	S.	Moderate		Clear.	Clear.
	4	24	38	30.10	30.10	S.	do		Hazy.	Hazy.
	5	34	32	29.70	29.36	NE.	do		Cloudy.	Cloudy.
	6	21	23	29.33	29.50	W.	Blustering		Cloudy.	Par. cloudy.
☾	7	12	22	29.70	29.75	W.	do		Par. Cloudy.	Clear.
	8	11	20	30.10	30.15	W.	Moderate		Clear.	Cloudy.
	9	12	26	30.27	30.27	W.	do		Clear.	Lightly cloudy.
	10	19	32	30.35	30.30	E.	do	.66	Cloudy.	Lightly rain.
	11	41	40	29.60	29.66	W.	Blustering		Cloudy.	Clear.
	12	33	38	29.83	29.83	W.	do		Par. Cloudy.	Clear.
	13	24	24	30.05	30.05	NE.	Moderate		Flying clouds.	Cloudy.
☉	14	23	23	29.90	29.83	NE.	Blustering		Cloudy.	Cloudy.
	15	29	24	29.45	29.45	W.	do	.65	Sleet,	Cloudy.
	16	12	29	29.90	29.95	W.	Moderate		Clear.	Cloudy.
	17	13	25	30.10	30.00	W.	do		Clear.	Cloudy.
	18	11	25	30.24	30.00	SE.	do		Cloudy.	Hazy.
	19	19	33	30.05	29.90	NE.	do		Cloudy.	Clear.
	20	33	37	29.60	29.90	W.	do		Par. Cloudy.	Clear.
☽	21	22	30	29.50	29.50	NW.	Brisk		Cloudy.	Par. cloudy.
	22	30	35	29.55	29.37	SE.	Moderate	.16	Cloudy.	Snow.
	23	14	28	29.80	29.80	W.	Brisk		Clear.	Clear.
	24	24	36	29.80	29.75	E SE.	Calm		Cloudy.	Lightly cloudy.
	25	22	38	29.70	29.70	W.	do		Clear.	Lightly cloudy.
	26	30	47	29.80	29.50	W.	do		Clear.	Lightly cloudy.
	27	31	43	29.50	29.50	W.	do		Clear.	Lightly cloudy.
⊗	28	28	39	30.00	30.00	E.	do	.07	Clear.	Lt. cloud. snow.
		22.96	31.14	29.82	29.80			1.48		

Thermometer.		Barometer.	
Maximum 47 on 26th. Minimum 11 on 8th & 18th.	Mean, 27.05	Max. 30.35 on 10th. Min. 29.33 on 6th.	Mean 29.5

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

NOVEMBER, 1843.

Civil Engineering.

Experiments on Water-Wheels, having a vertical axis, called Turbines. By Arthur Morin, Captain of Artillery, Professor of Machinery in the School of Artillery, &c. &c. *Published at Metz, and Paris,* 1838.

(Translated from the French, by Ellwood Morris, Civil Engineer.)

[Continued from Page 252.]

X.

Observations on the results of the Experiments.

The great velocity of the wheel, hindering our counting its revolutions by the eye, we arranged hard by a key-wedge, a spring-blade, which it struck at each turn, and two observers, guided by the sound, counted at the same time the number of turns made in one minute, repeating the experiments several times to ensure accuracy.

The total fall was measured for each experiment by the simultaneous observation of two floats, one placed above in the trough, and the other below in the lower basin. These floats, graduated, and marked at fixed points, were placed in little cases, and in situations suitable to protect their indications from the influence of undulations of the level (or waves.) The float below served also to determine the depth to which the lower ring of the *turbine* was immersed.

All these arrangements being made, we proceeded to the execution of the experiments, of which the results are recorded in the following table:

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Experiments made in May, 1837, on the Turbine of the Power Weaving Establishment of Moussay, (Department of Vosges.)

Number of the experiments.	*Lift* of the sluice-gate of the Turbine.	*Charge* of water on the sill, or edge, of the *water-board*, 2.682 metres in breadth.	*Weight* of water expended per sec.	*Total fall.*	Absolute Work or Power expended by the Motor. No. of kilogrammes lifted one metre in one second.	Absolute Work or Power expended by the Motor. No. of horses-power of 75 kilogrammes lifted one metre in one second.	*Load* of the *Brake*, or Friction Dynamometer.	*Turns* of the wheel in *one minute.*	*Velocity* that the point of suspens'n of load tended to take in 1 *second.*	Useful effect meas'd by the Brake, or quantity of available force. No. of kilogrammes lifted one metre, in one second.	Useful effect meas'd by the Brake, or quantity of available force. No. of horses power lifted one metre, in *one second.*	*Ratio* of *Useful Effect* meas'd. by *Brake* to the total power expended by Motor.	*Depth* which the *Turbine* was immersed, measured above *lower ring.*
	Metres	Metres	Kil.	Mtrs.	Kilog.	Hrs. pr.	Kilg.	No.	Mtrs.	Kilog.	Hrs. pr.		Mtrs.
1	0.0500	0.179	362	7.091	2567	34.25	7.50	255	66.81	501	6.68	0.195	0.307
2	0.0490	0.179	362	7.056	2554	34.18	10.50	240	62.88	659	8.78	0.258	0.302
3	0 0465	0.179	362	7.160	2592	34.52	12.50	222	58.16	726	9 68	0.280	0.303
4	0.0500	0.184	372	7.255	2697	35.96	12.50	243	63.67	795	10.60	0.295	0.303
5	0.0500	0.1815	364	7.229	2624	35.00	15.50	228	59.74	925	12.33	0.352	0.301
6	0.0500	0.181	363	7.131	2588	34.51	17.50	221	57.90	1013	13.31	0.35[illegible]	0.301
7	0.0500	0.1755	349	6.927	2419	32.26	20.50	210	55.02	1128	15.02	0 466	0.301
8	0.0470	0.185	373	7.127	2659	35.46	22 50	190	49.78	1120	14.93	0.420	0.296
9	0.0480	0.1755	349	7.313	2551	34.02	25.50	190	49.78	1267	16.89	0.497	0.295
10	0.0480	0.179	360	7.239	2606	34.75	27.50	178	46.64	1281	17.08	0.496	0.296
11	0.0480	0.176	351	7.294	2553	34.04	30.50	168	44.02	1342	17.89	0.525	0.294
12	0.0480	0.176	351	7.134	2504	33.39	32.50	163	42.71	1387	18.49	0.55[illegible]	0.294
13	0.0480	0.174	345	7.034	2427	32.36	35.50	153	40.09	1423	18.97	0.586	0.294
14	0.0480	0.175	348	6.854	2384	31.78	37.50	152	39.82	1492	19.89	0.626	0.294
15	0.0470	0.187	378	7.395	2795	37.27	40.50	146	38.25	1547	20.62	0.553	0.293
16	0.0510	0.188	387	7.375	2854	38.05	42.50	152	39.82	1691	22.54	0.593	0.293
17	0.0510	0.184	375	7.087	2657	35.43	47.50	135	35.37	1667	22.22	0.627	0.293
18	0.0500	0.181	366	6.911	2529	34.05	52.50	108	29.30	1486	19.80	0.587	0.287
19	0.075	0.230	523	7.278	3807	50.76	32.50	240	62.88	2044	27.25	0 587	0.395
20	0.072	0.233	534	7.333	3914	52.20	37.50	228	59.74	2238	29.84	0.572	0.360
21	0.079	0.235	540	7.105	3837	51.16	42.50	227	59.47	2528	33.70	0.659	0.353
22	0.073	0.235	540	7.285	3934	52.45	47.50	207	54.23	2574	34.32	0 654	0.350
23	0.073	0.227	515	7.150	3682	49.06	52.50	173	45.33	2378	31.70	0.643	0.348
24	0.071	0.226	523	6.951	3635	48.46	57.50	150	39.30	2260	30.12	0.622	0.342
25	0.071	0.228	520	6.986	3633	48.44	62.50	138	36.16	2257	30.08	0.621	0.342
26	0.071	0.225	522	7.017	3633	48.84	67.50	120	31.44	2119	28.25	0.578	0.341
27	0.071	0.224	512	7.019	3594	47.92	72.50	106	27.77	2015	26.86	0.561	0.341
28	0.071	0.222	502	7.002	3515	47.00	77.50	98	25.68	1984	26.45	0.565	0.341
29	0 071	0.224	512	6.994	3579	47.72	82.50	84	22.01	1816	24.20	0.506	0.343
30	0.071	0.227	515	7 046	3629	48 38	87.50	76	19.91	1742	23.20	0.480	0.342
31	0.071	Measurement by waste-board omitted.	525	7.522	3948	52.64	42.50	222	58.16	2472	32.95	0.626	0.256
32	0.071		527	7.562	3984	53.12	52.50	201	52.66	2765	36.86	0.696	0 256
33	0.071		527	7.563	3985	53.13	62.50	158	41.40	2587	34.49	0.651	0.255
34	0.071		527	7.554	3979	53.03	72.50	130	34.02	2466	32.88	0.623	0 264
35	0.071		529	7.554	3920	52.30	82.50	102	26.72	2204	29 39	0.561	0.264
36	0.071		527	7.556	3979	53.05	92.50	80	20.96	1939	25.85	0.486	0.282

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Number of the experiments.	Lift of the sluice-gate of the *Turbine*.	Charge of water on the sill, or edge, of the *waste board*, 2.682 metres in breadth.	*Weight* of water expended in *one second*.	*Total fall.*	Absolute Work or Power expended by the Motor. No. of kilogrammes lifted one metre in one second.	No. of horses-power of 75 kilogrammes lifted one metre in one second.	*Load* of the *Brake*, or Friction Dynamometer.	*Turns* of the wheel in *one minute*.	*Velocity* that the point of suspens'n of the load tended to take *per sec.*	Useful Effect measured by the Brake, or quantity of available power. No. of Kilogrammes lifted one metre in one second.	No. of horses-power lifted one metre in one second.	*Ratio* of *Useful Effect* meas'd. by *Brake*, to total power expended by the Motor.	*Depth* which the *Turbine* was immersed, measured above *lower ring*.
	Mtrs.		Kilo.	Mtrs.	Kilog.	Hrs. pr.	Kilo.	No.	Mtrs.	Kilog.	Hrs. pr.		Mtrs
37	0.086	Measurement by waste-board omitted, and quantities of water calculated by the coefficients of discharge of the Turbine orifices.	616	7.421	4571	60.94	42.50	250	65.50	2784	37.11	0.609	0.352
38	0.086		618	7.476	4622	61.63	52.50	220	57.64	3024	40.32	0.655	0.342
39	0.086		620	7.484	4638	61.80	62.50	184	48.21	3013	40.16	0.650	0.334
40	0.086		620	7.498	4649	61.99	72.50	155	40.61	2944	39.25	0.634	0.320
41	0.086		620	7.503	4657	62.09	82.50	128	33.14	2734	36.45	0.586	0.305
42	0.086		620	7.511	4664	62.19	92.50	108	28.30	2617	34.89	0.562	0.287
43	0.107		729	6.779	4943	65.90	42.50	250	65.50	2784	37.11	0.562	0.974
44	0.107		730	6.858	5008	66.77	52.50	240	62.88	3302	44.03	0.657	0.930
45	0.107		732	6.911	5058	67.44	62.50	208	54.50	3406	45.41	0.675	0.887
46	0.107		736	6.942	5115	64.87	72.50	169	44.29	3212	42.82	0.662	0.856
47	0.107		736	6.950	5115	64.87	82.50	144	37.73	3110	41.87	0.640	0.848
48	0.107		738	6.965	5137	68.49	92.50	122	31.96	2957	39.40	0.560	0.836

Observations on the foregoing Table.

In the experiments from 31 *to* 48 *inclusive*, we had removed the wasteboard, to enable us to use the whole of the ordinary fall.

In the experiments from 37 *to* 42 *inclusive ;* to calculate the quantity of water emitted in *one second*, we took 0.86 for the coefficient of the discharge due to the orifices of the *turbine.*

In the experiments from 43 *to* 48 *inclusive ;* to calculate the volume of water emitted in *one second*, we took 0.83 for the coefficient of discharge due to the orifices of the *turbine :* and we had increased the depth, to which the turbine was submerged, by a stop-gate in the tail-race (so as to flood it with back water).

[**Note.—Instead of the name *Friction Dynamometer*, we shall, hereafter, use its synonyme, *Brake*.—Trans.**]

XI.

Discussion and graphic representation of the results contained in this Table.

To examine and discuss the results contained in this table, we have constructed the curves below, of which the abscisses are the number of turns made by the wheel in *one minute*, and the ordinates represent the ratios of the useful effect measured by the *brake*, or of the available work, to the total power expended by the *motor.*

In tracing the curves through all the points thus determined for

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results, we have obtained one prolonged graphic law, free from the accidental irregularities of the observations. It is by the aid of an examination of these curves that we shall discuss the results of the experiments.

The curve, Fig. 1, Plate I, which relates to the series where the lift of the *sluice-gate* was at a mean 0.050 metres, or $\frac{16}{100}$ of a foot, shows that the maximum of effect corresponded to a velocity of 135 turns in *one minute*, and that then the ratio of the nseful effect, to that of the total power of the motor, was equal to about 0.61, although the calculation, based on the corresponding experiment, had given 0.625. But we see that from the velocity of 100 turns, to that of 170 turns per minute, this ratio has always been comprised between 0.565 and 0.610, so that even within these wide limits, it has not varied more than $\frac{1}{13}$th of its mean value, 0.587.

The curve, Fig. 2, Plate I, relating to the series of experiments where the lift of the *sluice-gate* of the *turbine* was 0.071 metres, or $\frac{23}{100}$ of a foot, shows that the maximum effect corresponded to the velocity of 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.680, although the calculation, based upon experiment, had given 0.696. We see also that from the velocity of 130 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.625 and 0.680; so that even between these wide limits, it has varied only about $\frac{1}{12}$th of its mean value, 0.652.

The curve, Fig. 3, Plate I, relates to the series where the lifts of the sluice-gate of the turbine had been 0.086 metres, or $\frac{28}{100}$ of a foot, and 0.107 metres, or $\frac{35}{100}$ of a foot; these we have united to obtain a more correct trace, but we have distinguished the points of each by particular signs. This curve shows that the maximum effect corresponded to a velocity of from 180 to 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.690. We see also that from the velocity of 140 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.650 and 0.690; so that between these wide limits it varied only $\frac{1}{17}$th of its mean value, 0.675.

It evidently follows from this discussion, that this wheel possesses the very remarkable and advantageous property of moving at extremely different velocities without much variation in its useful effect.

XII.

Observations on the advantage which this wheel possesses of being able to move at very different velocities (without much variation of useful effect.)

In many manufactures the velocity of the tool, and, consequently of the working point, must vary with the degree of forwardness of the work, and as it is always of importance to realize the maximum effect due to each case, the signal advantage of the turbine for such works is evident. But it is not less in those where the velocity is required to remain constant, even though the height of the

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the upper level, or the exhaustion of the lower; for the velocity of the wheel corresponding to the maximum effect depending on the total height of this fall, it follows that to obtain this maximum, we must contrive that the velocity of the wheel shall vary with the fall, but this, by hypothesis, the nature of the manufacture does not permit; whilst, by the property which these *turbines* have of being able to move at velocities very different from that which corresponds to the maximum effect, without the useful effect differing much from this limit, we see that with it we shall be able always to give to the tools, the velocity proper for the work, without losing any considerable part of the power of the motor. We shall see, by experiments, reported farther on, that this constancy of the useful effect held good for falls very different from those of Moussay.

XIII.

Remarks relative to the experiments in which the wheel was entirely submerged by backwater.

We shall observe also that in the experiments recorded in the preceding table, the level of the water below, rose, for the first series, to (0.300 m.) $\frac{98}{100}$ of a foot, above the lower ring of the turbine, and for the last series, to near (a metre) $3\frac{28}{100}$ feet, and that, nevertheless, the useful effect observed in this last series, has not been less, though the backwater was greater, than in the preceding. This result confirmed those which have been observed on the turbine of Moal, and shows again, that these wheels can move, when immersed, without their useful effect being sensibly diminished by the resistance of the water which surrounds them.

XIV.

Observation on the increase of the useful effect in proportion as the lift of the sluice-gate augments.

We shall now observe that the useful effect is perceptibly greater for those lifts of the sluice-gate which approach to the height of the turbine, than for those which are less; but as this effect is exhibited in a way more evident in the experiments made at Müllbach, we reserve the explanation of it for that part of the subject. Nevertheless, we shall remark, that with a lift of the sluice-gate of $\frac{16}{100}$ of a foot (0.05 m.), nearly half of the height of the turbine, the useful effect is about 0.61 of the absolute work, or power, expended by the motor, and it approached more nearly to the value 0.69, when the lift reached (0.107 m.) $\frac{35}{100}$ of a foot, (or nearly the whole height of the *turbine.)*

XV.

Summary of the results drawn from these experiments.

1. That the wheel of the weaving establishment of Moussay, which had but about (0.85 m.) $2\frac{79}{100}$ feet of external diameter, and (0.11 m.) $\frac{36}{100}$ feet of height of ring, under a fall of (7.50 m., or 24 $\frac{61}{100}$ feet,) is able to vent a volume of water of (0.738 cub. m.) $26\frac{04}{100}$ cub. feet in

a second; and, moreover, that it then transmitted *a useful effect, or available power, of more than* 45 *horses, each equal to* (75 kil. lifted 1 m. in 1 sec.) 32,553 *lbs. lifted one foot high in a minute.* [Which is so nearly the same as the *horse-power* of Boulton and Watt's steam standard, that it may be taken as identical therewith, which will be hereafter understood whenever the phrase *horse-power* is used.—Tr.]

2. That with the velocity of 180 to 190 turns in a minute, it returned, in available power, 0.69 of the absolute power expended by the motor, (or the *effect* produced, was to the *power* expended, as 0.69 to 1.)

3. That the velocity of the wheel may vary within very wide limits, without the useful effect abating more than $\frac{1}{12}$th to $\frac{1}{15}$th of its maximum value.

4. That the ratio of the useful effect to the power expended, does not diminish, when the wheel is submerged by backwater.

Experiments on the Turbine of the Power Weaving Establishment of Müllbach (Lower Rhine).

XVI.

Summary Description.

The power weaving establishment constructed in 1837, at Müllbach, in the department of the lower Rhine, has, for its motor, a *turbine* of about (2 m.) $6\frac{56}{100}$ feet in diameter; the mean power of which ought to be 45 horses. In compliance with my request, the intelligent proprietors, the Messrs. Sellière, Heevoot & Co., readily consented to make all the arrangements necessary for submitting this wheel to experiment. M. Schedecker, their partner, director of the spinning factory of Lutzelhausen, and also of this, willingly took upon himself to make suitable preparations; and on the 28th, 29th, and 30th of last July, the experiments were made in presence of M. Schedecker, M. Fourneyron, and several manufacturers and civil engineers.

The turbine is situated at the end of the canal of supply, in a chamber of (6.55 m. by 5.70 m.) $21\frac{49}{100}$ feet by $18\frac{70}{100}$ feet, in the floor of which is placed the cylinder which contains the sluice-gates. A hollow pipe which rises vertically, supports, by its lower extremity, the plate on which the curved guides are fixed, and it joins, by its upper extremity, to the apparatus which serves for raising the sluice-gate, and which receives the supports of the end of the lying shaft.

The shaft of the turbine enters within this cylinder, and passes out by the top, where it receives a beveled wheel, which transmit the motion to the lying shaft of the workshop, into which this shaft enters a little below the ground floor.

The *turbine* is placed below the floor of the water chamber, so that when this chamber is full, we cannot see either the sluices, or the wheel. The canal of escape, of which the direction is perpendicular to that of the canal of supply, has (6.40 m.) 21 feet of breadth, and is arched over for (20 m.) $65\frac{62}{100}$ feet beyond the building of the factory, under which it passes.

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The work is fed by the waters of the Brasche, and the total fall is usually (4.50 m.) 14 $\frac{76}{100}$ feet; but at the time when these experiments were made, the stop-gate, which ought to withdraw the waters of the river into the canal of supply, was not yet executed, and the greatest fall of which we had the power to dispose, was only (3.70 m.) 12$\frac{14}{100}$ feet. In freshets, the wheel becomes immersed, and it was so during all the experiments, to a depth which varied from about (0.520 m.) 1$\frac{71}{100}$ feet, to (0.90 m.) 2$\frac{95}{100}$ feet.

XVII.

Gauge of the expenditure of water.

To operate easily and accurately in gauging the expense of water, we had established at the end of the arch of the canal of escape, a stop-gate with an overfall, or waste-board, of (5.014 m.) 16 $\frac{45}{100}$ feet in breadth, of which the sill, or edge, formed by a thin plank of (0.027 m.) one inch thick, was (0.50 m.) 1$\frac{64}{100}$ of a foot, to (0.60 m.) 1$\frac{97}{100}$ of a foot from the bottom, and of which the vertical sides were each at (0.70 m.) 2$\frac{30}{100}$ feet from the borders of the canal. The horizontal lines of reference established with care, admitted of easily measuring, at each experiment, the height of the level of the reservoir from (0.60m.) 1$\frac{97}{100}$ of a foot upwards, and in the angles of the canal above the sill. From these circumstances of the establishment of this waste-board, or overfall, and the results of recent experiments made at Toulouse, and of which a part has been published by M. d'Aubuisson, we have taken to calculate the discharge of water in *one second,* the formula,

$$^{*}\, Q = 0.41\, LH \sqrt{2gH},$$

[which differs but a trifle from that already employed; see article VIII.—Trans.]

But the water chamber having its bottom, and one of its sides, of wood, the wood drying by the heat of the season, and not having time to swell sufficiently, since it was filled (with water,) leaked considerably at the joints, and this it was necessary to take into account. This we did at the beginning of each series of experiments, by observing the depth of water on the waste-board of the gauge, when the sluices of the turbine were closed. The results of these observations are shown in the table of the experiments, and the volume of water thus lost, has been deducted from that which corresponds to the charge observed on the waste-board during the experiments.

XVIII.

Arrangements made to measure the principal results.

For obtaining the total fall, we arranged a horizontal line of reference, at a known height, above the plane of the sluices upwards,

* I believe I ought to make the remark, that in those experiments, which I have published before, on the breast-wheel of the slitting mill of Balcarat, I have adopted the formula,

$$Q = 0.395\, LH \sqrt{2gH},$$

not knowing then of the experiments at Toulouse, this induced me to estimate the discharge at about 1.26th be ow its value.

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canal of escape. The difference gave, for each experiment, the available fall, and the excess of the height of the line of reference above the plane of the sluices, over the elevation of the same line above the water below, gave the depth to which the lower ring of the turbine was immersed.

XIX.

Of the Brake employed.

The brake was formed by a pulley of (1.25 m.) $4\frac{10}{100}$ feet in diameter, and of about (0.25 m.) $\frac{82}{100}$ of a foot broad at the throat, which had been turned with care, and well centred and wedged upon the upper part of the shaft of the turbine, which had not yet received the gearing which belonged there. The two jaws of this brake were of wood; the length of the lever measured perpendicularly to the direction of the cord to which the charge was suspended, was (2.99 m.) $9\frac{81}{100}$ feet. A cord fixed to the top of the wood work at (*6 to 7 m.*) $19\frac{63}{100}$ to $22\frac{97}{100}$ feet high, sustained the ends of the lever, and a plumb line indicated the position which it ought to preserve, so that its length should be perpendicular to the direction of the cord, which passed over a fixed pulley, sustaining the load.

XX.

Precautions to insure the regularity of the movement.

To maintain the surfaces in the same state of humidity, we introduced near the wheel, the fire engine of the establishment, and a watering pot was suspended above the cushion of the brake, in which a notch was made, whence the water poured on it. The men, in working the pump, directed a constant and regular current upon the rubbing surfaces, which were thus continually cooled and lubricated to the same degree. We obtained, in this manner, such regularity in the action of the brake, that, when under the same charge, it has sometimes moved more than one half hour without the least oscillation, so that the workman who superintended it, was not obliged to alter its screws. In one of the experiments, which we report, the oscillations of the lever below the vertical of the plumb-line, had not exceeded (0.02 to 0.03 m.) $\frac{6}{100}$ to $\frac{9}{100}$ of a foot either way, and the stay pieces disposed as a precaution, acted only during the moments of interruption.

We have not used a kilogramme of grease in making all these experiments, and, although I had frequently employed this dynamometrical apparatus with success, I had never seen it move with such perfect regularity.

Thus aided by these easy and very available means, I consider as entirely useless superfluities, all the modifications proposed, or adopted, by divers engineers, in the simple arrangement originally proposed by M. de Prony.

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XXI.

Observations on the velocity of the Wheel.

The observations on the velocity of the wheel have been made almost always by two persons, and by repeated trials, by counting with second-watches, the number of turns made in *a minute*, by the shaft of the wheel.

The results of the experiments, and those that we deduce from them by calculation, are recorded in the following table.

Observations on the following Table.

In the experiments from 1 *to* 18 *inclusive;* the depth of water on the sill of the waste-board, arising from leakage, was 0.0265 m., which corresponds to *a loss of water of* 0.039 *cubic metres in a second,* which we have deducted from the volume which passed the waste-board during the experiments. It is the weight of the volume remaining, which is indicated by the fourth column.

In the experiments from 19 *to* 45 *inclusive;* the depth of the water on the sill of the waste-board, arising from the leakage, was 0.037 m., which corresponds to *a loss of water of* 0.064 *cubic metres in a second,* which we have deducted from the volume which passed the waste-board during these experiments.

In the experiments from 46 *to* 49 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second,* and in the 46th experiment, it passed, besides in discharging 0.011 cubic metres in a second. These volumes expended, *in pure loss,* have all been deducted from those which passed the waste-board during the experiments.

In the experiments from 50 *to* 84 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second,* which we have deducted from the volume of water which passed the waste-board during the experiments.

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Number of the experiments.	Lift of the Sluice-gate.	Depth of water on the sill of the Waste-board, 5.014 m. in breadth.	Weight of water expended in one second.	Total Fall.	Absolute Power expended by the Motor: No. of kilogrammes lifted one metre in one second.	Absolute Power expended by the Motor: No. Horses-power.	Load of the Brake.	Turns of the Wheel in one minute.	Velocity which the point of susp'n. of load tended to take per second.	Useful Effect measur'd by the Brake, or quantity of available Power: No. of kilogrammes lifted 1 metre in 1 second.	Useful Effect measur'd by the Brake, or quantity of available Power: No. Horses-power.	Ratio of Useful Effect measured by the Brake, to the total power of the Motor.	Depth the Turbine was immersed, measured above the lower ring.
	Mtrs.	Mtrs.	Kilog.	Mtrs.	Kilog.	Hrs. pr.	Kilog.	No.	Mtrs.	Kilog.	Hr. pr.		Mtrs.
1	0.050	0.174	622.5	3.552	2208	29.44	8.13	72.0	22.54	183	2.44	0.083	0.520
2	“	0.174	622.5	3.547	2209	29.44	13.13	67.9	21.26	278	3.70	0.126	“
3	“	0.174	622.5	3.560	2213	29.51	18.13	64.8	20.48	371	4.93	0.167	“
4	“	0.174	622.5	3.580	2226	29.68	23.13	63.1	19.74	457	6.09	0.225	“
5	“	0.174	622.5	3.580	2226	29.68	28.13	60.0	18.80	429	7.00	0.238	“
6	“	0.174	622.5	3.565	2214	29.52	33.13	57.6	18.05	598	7.63	0.252	“
7	“	0.172	611.0	3.555	2170	28.93	38.13	55.3	17.35	662	8.82	0.306	“
8	“	0.172	611.0	3.565	2184	29.12	43.13	53.3	16.75	722	9.62	0.331	“
9	“	0.172	611.0	3.580	2187	29.16	48.13	50.7	15.90	765	10.20	0.350	“
10	“	0.173	610.0	3.58[illegible]	2193	29.24	53.13	47.6	14.90	792	10.88	0.357	“
11	“	0.173	610.0	3.621	2208	29.44	58.13	43.9	13.76	800	10.99	0.373	“
12	“	0.173	610.0	3.621	2208	29.44	63.13	40.9	12.80	808	10.77	0.367	“
13	“	0.173	610.0	3.650	2223	29.64	68.13	37.5	11.72	798	10.64	0.360	“
14	“	0.173	610.0	3.680	2247	29.96	73.13	34.25	10.70	785	10.46	0.350	“
15	“	0.174	622.5	3.703	2301	30.34	78.13	31.0	9.70	758	10.10	0.332	“
16	“	0.174	622.5	3.725	2315	30.87	83.13	28.1	8.80	732	9.75	0.315	“
17	“	0.174	622.5	3.730	2322	30.96	88.13	26.85	8.32	733	9.77	0.316	“
18	“	0.174	622.5	3.750	2219	26.92	93.13	21.7	6.80	667	8.89	0.296	“
19	0.090	0.262	1156.	3.224	3727	49.69	35.	75.0	23.26	814	10.85	0.218	0.926
20	“	0.253	1087.	3.199	3479	46.38	50.	69.0	21.60	1080	14.40	0.311	0.926
21	“	0.254	1101.	3.208	3532	47.09	60.	65.0	20.36	1221	16.28	0.346	0.877
22	“	0.250	1071.	3.210	3438	45.84	70.	61.6	19.30	1351	18.01	0.392	0.875
23	“	0.250	1071.	3.196	3420	45.60	80.	59.2	18.55	1484	19.78	0.432	0.874
24	“	0.250	1071.	3.177	3417	45.33	90.	56.0	17.52	1577	21.02	0.462	0.875
25	“	0.245	1036.	3.190	3305	44.06	100.	52.0	16.29	1629	21.72	0.492	0.875
26	“	0.241	1016.	3.190	3241	43.21	110.	49.2	15.42	1696	22.61	0 523	0.865
27	“	0.241	1016.	3.207	3250	43.44	120.	45.25	14.19	1703	22.70	0.524	0.870
28	“	0.241	1016.	3.207	3258	43.44	130.	41.0	12.82	1667	22.22	0.512	0.870
29	“	0.240	1008.	3.215	3236	43.15	140.	37.2	11.64	1630	21.72	0.504	0.875
30	“	0.240	1008.	3.225	3244	43.25	150.	35.0	10.95	1643	21.90	0.506	0.875
31	“	0.236	971.	3.265	3162	42.16	160.	32.5	10.26	1642	21.88	0.520	0.865
32	“	0.236	971.	3.305	3209	42.78	170.	29.5	9.25	1573	20.96	0.490	0.865
33	“	0.237	976.	3.295	3190	42.53	180.	27.5	8.61	1550	20.66	0.485	0.865
34	0.150	0.354	1881.	3.164	5952	79.36	20.	99.5	31.10	622	8.29	0.105	0.960
35	“	0.349	1786.	3.164	5648	75.30	40.	92.0	29.10	1164	15.52	0.205	0.960
36	“	0.345	1781.	3.150	5543	73.90	60.	90.0	28.15	1689	22.52	0.305	0.960
37	“	0.343	1751.	3.153	5513	73.50	80.	83.5	26.10	2088	27.84	0.378	0.940
38	“	0.342	1747.	3.110	5433	72.44	100.	78.5	24.55	2455	32.73	0.453	0.953
39	“	0.337	1766.	3.070	5424	72.32	120.	73.0	28.05	3366	44.88	0.621	0.965
40	“	0.331	1666.	3·070	5124	68.32	140.	69.0	21.60	3024	40.32	0.591	0.965
41	“	0.326	1641.	3.075	5046	67.28	160.	63.0	19.70	3152	42.03	0.624	0.965
42	“	0.322	1586.	3.035	4731	63.08	180.	58.25	18.25	3285	43.80	0.696	0.965
43	“	0.320	1576.	3.085	4863	64.84	200.	52.0	16.29	3258	43.44	0.671	0.955
44	“	0.318	1561.	3.085	4816	64.21	220.	48.0	15.01	3302	44.03	0.685	0.955
45	“	0.312	1526.	3.085	4703	62.70	240.	44.0	13.79	3172	42.28	0.675	0.855

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Number of the experiments.	Lift of the Sluice-gate.	Depth of water on the sill of the Waste-board, 5.014 m. in breadth.	Weight of Water expended in one second.	Total Fall.	Absolute Power expended by the Motor. No. kilogrammes lifted one metre in one second.	Absolute Power expended by the Motor. No. Horses-power.	Load of the Brake.	Number of Turns of the Wheel in one minute.	Velocity which the point of suspens'n. of the load tended to take in 1 second.	Useful Effect measured by the Brake, or quantity of available Power. No. kilogrammes lifted one metre in one second.	Useful Effect measured by the Brake, or quantity of available Power. No. Horses-power.	Ratio of Useful Effect measured by the Brake, to the total power of the Motor.	Depth the Turbine was immersed, measured above the lower ring.
	Mtrs	Mtrs	Kilog.	Mtrs.	Kilog.	Hrs. pr.	Kilog.	No.	Mtrs.	Kilo.	Hrs. pr.		Mtrs.
46	0.150	0.331	1652.	3.380	5583	74.44	260.	45.8	14.20	3692	49.22	0.662	0.865
47	"	0.313	1528.	3.272	5000	66.66	280.	38.0	11.89	3329	44.38	0.666	0.850
48	"	0.313	1528.	3.400	5187	69.16	280.	38.5	12.05	3374	44.98	0.651	0.950
49	"	0.313	1528.	3.405	5192	69.22	300.	34.4	10.79	3337	43.16	0.626	0.820
50	0.200	0.380	2053.	3.020	5857	78.09	10.	104.	32.55	326	4.34	0.055	0.890
51	"	0.377	2033.	3.045	6186	82.48	20.	103.	32.25	645	8.60	0.104	0.890
52	"	0.375	2025.	3.080	6237	83.16	40.	101.5	31.75	1270	16.93	0.203	0.890
53	"	0.373	2003	3.120	6256	83.41	60.	95.	29.70	1782	23.76	0.280	0.890
54	"	0.371	1993.	3.170	6332	84.42	80.	90.4	28.25	2260	30.13	0.357	0.890
55	"	0.371	1993.	3.190	6357	84.76	100.	87.1	27.15	2715	36.20	0.426	0.885
56	"	0.365	1951.	3.208	6249	83.32	120.	82.8	25.9[illegible]	3108	41.44	0.496	0.885
57	"	0.361	1913.	3.240	6198	82.64	140.	80.	25.00	3500	46.66	0.565	0.885
58	"	0.361	1913.	3.255	6227	83.02	160.	75.	23.48	3737	50.09	0.604	0.885
59	"	0.361	1913.	3.270	6255	83.40	180.	70.	21.96	3942	52.56	0.632	0.880
60	"	0.361	1913.	3.305	6313	84.17	200.	67.6	21.16	4232	56.42	0.671	0.880
61	"	0.361	1913.	3.310	6331	84.41	200.	67.1	21.90	4200	56.00	0.664	0.870
62	"	0.353	1872.	3.310	6182	82.42	220.	63.	19.70	4334	57.78	0.702	0.870
63	"	0.353	1872.	3.335	6228	83.04	240.	58.	18.15	4356	58.08	0.700	0.870
64	"	0.349	1812.	3.306	5991	79.88	26[illegible].	50.6	15.84	4118	54.91	0.686	0.884
65	"	0.349	1812.	3.286	5960	79.46	280.	48.5	15.16	4245	56.59	0.712	0.884
66	"	0.349	1812.	3.321	6017	80.23	300.	44.	13.79	4137	55.16	0.690	0.884
67	"	0.392	2173.	3.610	7860	104.80	90.	10[illegible].	31.25	2813	37.50	0.357	0.640
68	"	0.383	2082.	3.650	7615	101.53	110.	97.	30.30	3339	44.51	0.440	0.640
69	"	0.388	2143.	3.560	7643	101.90	130.	91.	28.50	3705	49.40	0.485	0.610
70	"	0.384	2083.	3.475	7253	96.70	150.	87.	27.20	4080	54.40	0.562	0.680
71	"	0.378	2061.	3.300	6815	90.87	170.	80.	25.03	4255	76.70	0.626	0.680
72	"	0.371	1983.	3.250	6458	86.11	190.	72.	2[illegible].60	4312	57.79	0.670	0.680
73	"	0.367	1943.	3.230	6289	83.85	210.	67.	20.90	4389	58.52	0.700	0.680
74	"	0.364	1933.	3.358	6505	86.73	230.	62.1	19.43	4379	58.38	0.676	0.557
75	"	0.360	1908.	3.343	6392	85.23	240.	57.5	18.00	4500	60.00	0.703	0.557
76	"	0.356	1863.	3.392	6317	84.23	270.	54.	16.90	4563	60.84	0.721	0.557
77	"	0.356	1863.	3.398	6337	84.49	290.	49.4	15.46	4483	59.77	0.785	0.557
78	0.270	0.432	2523.	3.290	7562	100.82	170.	90.6	28.19	4592	61.22	0.609	0.750
79	"	0.432	2523.	3.070	7758	103.44	190.	87.	27.20	5168	68.90	0.670	0.750
80	"	0.422	2442.	3.170	7760	103.47	210.	84.6	27.5	5565	74.20	0.721	0.750
81	"	0.422	2442.	3.180	7750	103.33	250.	77.25	24.20	6050	80.66	0.785	0.750
82	"	0.422	2442.	3.310	8097	107.96	290.	69.	26.50	6264	83.52	0.760	0.720
83	"	0.432	2523.	3.475	8776	117.01	330.	66.1	27.20	6831	91.08	.707	0.720
84	"	0.423	2445.	3.390	8302	110.69	340.	61.5	8.19	6545	87.26	0.793	0.720

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Graphic representation and discussion of the results contained in the preceding Table.

To examine and unite the results contained in this table, we have the same as for the experiments on the turbine of Moussay, constructed curves having for abscisses the number of turns of the wheel in one minute, and for ordinates the ratio of the useful effect, to the total power of the motor.

The curve, Fig. 4, Plate I, relating to the series where the lift of the sluice-gate was (0.050 m.) $\frac{16}{100}$ of a foot, shows that, for this small lift, the useful effect rose only to 0.37 of the total power of the motor, and that from the velocity of 33 turns in a minute, to that of 51 turns, it was comprised between 0.35 and 0.37, so that between these wide limits, it varied but $\frac{1}{36}$th of its mean value.

The curve, Fig. 5, Plate I, relating to the series where the lift of the sluice-gate was (0.090 m.) $\frac{29}{100}$ of a foot, shows that the useful effect rose in this series to 0.725 of the total power of the motor, and that from the velocity of 26 turns in a minute, up to that of 55 turns, it was always comprised between 0.680 and 0.725, so that between these wide limits, it did not vary more than $\frac{1}{32}$nd of its mean value, 0.702.

The curve, Fig. 6, Plate I, relating to the series where the lift of the sluice-gate was (0.150 m.) $\frac{49}{100}$ of a foot, shows that the useful effect rose, in this series, to 0.690 of the total power of the motor, and that, from the velocity of 35 turns in a minute, to that of 65 turns, the useful effect was always comprised between 0.630 and 0.690, so that between these wide limits, it did not vary more than $\frac{1}{22}$nd of its mean value, 0.660.

The two curves, Fig. 7, Plate II, relating to the series where the lift of the sluice-gate was (0.200 m.) $\frac{66}{100}$ of a foot, refer, the lower one, to the series where the turbine was submerged (0.88 m.) $2\frac{89}{100}$ feet, and the upper one, to the series where it was so, but (0.64 m.) $2\frac{10}{100}$ feet. Their examination shows that, even to the velocity of 60 turns in a minute, the ratio of the useful effect to the total power of the motor, is the same for the two series, and rises for the case of the maximum to 0.710. We see further, that for the first series, from the velocity of 40 turns in a minute, up to that of 66 turns, this ratio has been constantly comprised between 0.675 and 0.710; so that even between these wide limits, it did not vary more than $\frac{1}{39}$th of its mean value, 0.692.

For the second case where the wheel was submerged only (0.64 m.) $2\frac{10}{100}$ feet, the ratio of the useful effect, to the total power of the motor, diminished less rapidly in proportion as the velocity augmented, and it remained comprised between the same limits of 0.675 to 0.710, from the velocity of 40 turns in a minute, to that of 72½ in a minute.

The curve, Fig. 8, Plate II, relating to the series where the lift of the sluice-gate, was (0.270 m.) $\frac{88}{100}$ of a foot, shows that the ratio of the useful effect, to the absolute power of the motor, was, at the maximum, 0.79, and that from the velocity of 55 turns in a minute, to

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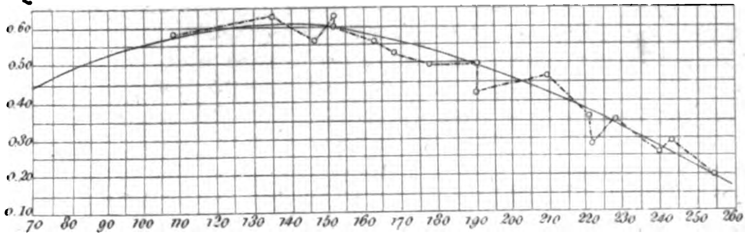
Fig.1.



1st Series o 2nd Series ×

Fig.2.

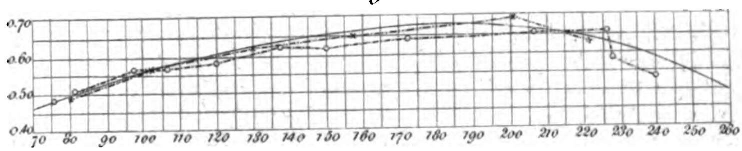


Fig. 3.

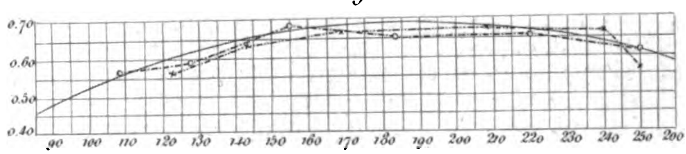


Fig. 4.

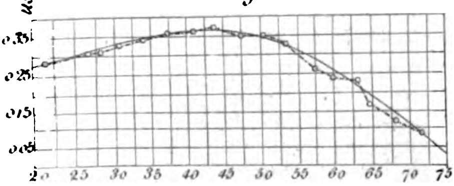


Fig. 5.

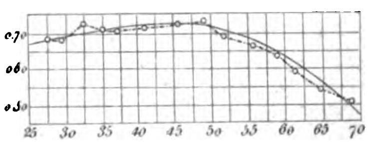
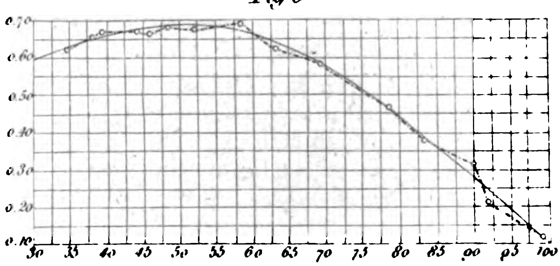


Fig 6



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so that even between these wide limits, it varied only $\frac{1}{37}$th of its mean value, 0.780.

After having examined particularly the results relative to each of the series of experiments, if we cast a glance over the whole, we see immediately that the ratio of the useful effect, measured by the brake, to the total power of the motor, is only 0.37 at the maximum for the first series, a result much inferior to those we had obtained for it in the other series. For explaining this difference, it appears to me proper to relate an observation, which I have had occasion to make, on the introduction of the water along a curved bucket of a form analogous to those of the turbines.

When we introduce by the outer border of a curved bucket, carried in its movement of rotation about a vertical axis, a filament of water possessing a certain velocity, as soon as the liquid reaches the surface of the buckets its velocity is altered, not only by the action of the centrifugal force which tends to remove it from the axis, but also by the adhesion which it contracts with the surface. The fluid vein becoming thin, rises along the bucket to a height the greater in proportion to the first velocity; it follows hence, that the relative velocity of the liquid is altered by two causes, and that a considerable portion of the active force of the liquid is consumed by its adhesion to the partition: moreover, if, as in the turbines, the buckets are short, and little raised, a part of the liquid can lose another portion of its velocity against the upper ring, whilst the other part, actuated by an ascending velocity, escapes to the outside, preserving a vertical velocity which it would not have acquired, if the buckets had not had a height equal to that of the filament of water. This shows besides, that the diminution of the useful effect in the case of small lifts of the sluice-gate, belongs to circumstances of this species, because we see the useful effect increases in proportion as the difference between the lift of the gate and the height of the turbine diminishes.

In effect, as soon as the height of the sluice-gate reaches (0.09 m.) $\frac{29}{100}$ of a foot, the useful effect becomes equal to about 0.71 of the total power of the motor, and for the stronger lifts which come near the height of the wheel, it reaches the value of 0.79 of the total power. The experiments, moreover, showed that for the discharges (of water) which varied from 1500 to 2500 kilogrammes in one second, the ratio of the useful effect, to the absolute power of the motor, is sensibly the same within these wide limits.

XXIII.

Observations relative to the experiments when the wheel was submerged.

We shall observe that the series of experiments relative to the lift of the sluice-gate of (0.200 m.) $\frac{66}{100}$ of a foot, where the wheel was only immersed from (0.64 m. to 0.56 m.) $2\frac{10}{100}$ to $1\frac{84}{100}$ feet, had given results more advantageous than those in which the depth of immersion was increased to (0.88 m.) $2\frac{89}{100}$ feet, as soon as the velocity had

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exceeded 60 to 65 turns in a minute. This effect ought, without doubt, to be attributed to this, that, in the second case, the mass of water to which the wheel communicated a gyratory movement, was greater than in the first, and, that the rubbing surface of the buckets was submitted to a greater pressure; but the velocity of the wheel, suitable to the maximum of effect, being comprised between 45 and 65 turns in a minute, it follows that within the common limits of these velocities, this difference in the depth of immersion has no important influence on the useful effect.

The last series of experiments, relative to a lift of the sluice-gate of (0.270 m.) $\frac{88}{100}$ of a foot, has given us a useful effect at the maximum of 91 horses, although the wheel had been constructed only for 45 to 50 horses, and we regretted not being able to push the experiments further, by increasing the load on the brake; but the cast-iron shaft of the turbine, having been proportioned only for a power of 40 to 45 horses, at a velocity of 50 to 60 turns in a minute; after having nearly doubled the load which it was meant to carry, we had not the courage to go further, from the fear of occasioning some permanent twist.

XXIV.

Conclusions from these Experiments.

1. That the turbine of the power-weaving establishment of Müllbach, which was only about (2 m.) $6\frac{56}{100}$ feet diameter, and (0.333 m.) $1\frac{09}{100}$ feet in height, could, under a fall of from (3.50 m. to 3.75 m.) $11\frac{48}{100}$ feet to $12\frac{30}{100}$ feet, expend a volume of water $88\frac{3}{10}$ cubic feet, or 2.5 cubic metres in a second, transmitting, then, *a useful effect, or available power, of* 91 *horses.*

2. That, at a velocity of 50 to 60 turns in a minute, and with a strong lift of sluice-gate, it rendered in *useful effect*, 0.78 *of the total power expended by the motor.*

3. That the velocity of the wheel could vary within very wide limits without the useful effect abating more than from $\frac{1}{25}$ to $\frac{1}{30}$ of its maximum value.

4. That the ratio of the useful effect, to the total power of the motor, did not diminish when the wheel was immersed about (1 m.) $3\frac{28}{100}$ feet, if it moved with a velocity not much exceeding that which belonged to the maximum of effect when it *was not* immersed.

5. That the expense of water having varied from 1500 to 2500 kilogrammes in a second, that is to say, in the ratio of 3 to 5, the ratio of the useful effect, to the total power, remained sensibly the same.

(To be continued.)

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

(Continued from Page 251.)

LECTURE XV.—WORKING EXPENSES OF RAILWAYS (*continued.*)

Having, in the last lecture, analyzed the working expenses of railways, in reference to the train, that is, reduced to a rate per train per

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sidered it might be well to consider the same subject in another light. In the preceding mode of calculation, no regard was paid to the amount of what might be called the useful weight carried. It seemed to the Professor, that the proportion between the dead weight of the engine, tender, and carriages, and the weight of the passengers and their luggage—in short, between the unprofitable and the profitable load—formed an important element for consideration, even if it did not affect the principle on which railways ought to be worked. In the common omnibus, with a full complement of passengers, the proportion was one to one—taking the average load, about five to three—or, including the weight of the horses (the moving power which has also to carry itself), about three to one, or, with a full load of passengers, something less than two to one. But, on the railway, owing to the far greater weight of the carriages, and general arrangement on most lines, the proportion of dead weight is much greater. In a first class carriage, as adapted for long lines, and fully loaded with passengers and their luggage, the proportion is two and a half to one; but, taking the average load, it is about four to one, and, when but little luggage is taken, four and a half and five to one. On short lines, where the trains run often, with many carriages, the proportion is sometimes as high as eight to one, or, including engine and tender, as twelve to one. In an ordinary train of about seven carriages, their weight, and that of the engine and tender, may be taken at about fifty tons; the average number of passengers, has, on a former occasion, been shown to be about sixty per train, or four tons without, and, perhaps, five tons with, their ordinary weight of luggage, and say one or two tons of packages and parcels paying freight, being a proportion of six or seven of unprofitable, to one of profitable load; and if the carriages were all full, about four and a half or five to one, as above, and, on the average, the proportion might very fairly be taken as at least five to one. It appeared to the Professor that there was some radical error here, and that some arrangements were wanting to reduce this proportion, as far as the carriages were concerned, for, of course, as long as the locomotive engine was used, its weight would always form a large proportion of the load, particularly with light trains—though the carriages certainly required to be made strong and heavy on this system—and this seemed an inherent defect on this principle of locomotion, perhaps quite irremedial. Yet, at all events, on many lines the proportion of dead weight of carriages was much too great, and might be remedied. Of late this had been done on the Greenwich Railway, where, by combining two classes of seats in the same vehicle, much fewer carriages sufficed. There was a great contrast to this on the Blackwall Railway, where, from having a separate carriage for each station, according to the peculiar mode of working that line, the proportion of dead carriage weight was generally about three, and often four, times as much as on the Greenwich, though the carriages were of the same build. Owing to this and to other causes, extra guards, rope, &c., notwithstanding the generally admitted economy of stationary power, the expense of working the Blackwall Rail-

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the average for the working on several locomotive lines, and quite as high, if not higher, than the present rate of working on the Brighton Railway, which was the highest of any that had yet come under his cognizance. Although, abstractedly, this over proportion of dead weight carried, was not always connected with the moving power, yet an engineer ought to point out, and, when within his control, to remedy such an evil, as the loss consequent on carrying useless weight is equivalent to that arising from increased resistance of gravity in surmounting an unnecessary ascent—a case which every engineer is naturally anxious to avoid.

In the mode of reducing railway expenses to a mileage, adopted in the last lecture, the number of passengers, and their proportion to dead weight of carriages, had not been considered, for it was clear that the arrangement of carriages in any train being supposed to be duly proportioned to the average traffic, any addition to the average assumed load would be pure profit, and would not cause any sensible addition to the cost of the transit of the regular load, for which all the necessary arrangements of engines, tenders, carriages, guards, stations, and the whole working and carrying establishment of the railway was already provided and paid for. But, suppose another mode of considering the working expenses be adopted, viz., from the number of passengers in a train, deduced from an average of many lines for several years, or from any assumed number per train, let the cost per passenger per mile be worked out, and this will lead to the consideration of the true policy for attracting the greatest number of persons, and trying to fill the trains up, as they must go, at any rate.

The Professor then went through the various items of railway expenses stated in the former lecture, and brought them out in decimals of a penny per passenger per mile—the result being, that, taking account of experience gained and applied, and economical arrangements duly introduced, the expense of locomotive power might be taken at ¼*d.* per passenger per mile, which was coming back to the original estimate made for the working of the London and Birmingham Railway. Other expenses, including government duty, would bring the total up to two-thirds of a penny, and, under favorable circumstances, of well filled carriages, this might sometimes be brought down to ½*d.*, but taking the average of lines as now worked, the cost was about 1*d.* per passenger per mile. On many of the American railways the cost was as low as ½*d.*, and for long lines on the continent, in India, &c., where wages were low, and coal or wood might be got very cheap for locomotive fuel, and no rates, or taxes, on profits and passengers were laid, the charge of carrying passengers per mile might be fairly taken at ½*d.* only. Now, if the proportion between the unprofitable and the profitable parts of the load were reduced to three to one, as regarded carriages only, and six to one as regards the whole weight of the train, the expense of carrying passengers, taken by weight, will be still at least three times as expensive as carrying goods only at the same velocity, the proportion being of wagons to goods as two to three, and of the whole train, including engine and tender,

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one to one, and for coal and mineral traffic, at diminished rates of traveling, still less. The Professor observed, that the cost of conveying merchandize might be taken at about 1*d.* per ton per mile for railway expenses only, exclusive of collection and distribution at the termini of lines, and that of coal and minerals at about ½*d.* per ton per mile. With these elements, therefore, of the expense of working railways either per train, or per passenger, or per ton, it is for the politic manager of a public concern to consider what should be the rate of charges above these cost prices to make to the public, so as to induce the greatest amount of traffic. Mr. Vignoles then observed, that there was a third way of considering the subject of the working expenses of railways, in reference to the number of engines employed, which was the mode adopted by the Irish Railway Commissioners, and which was, perhaps, the proper way of calculating the annual cost on lines of little intercourse, on which, however small the traffic might turn out to be, yet a certain number of engines must be kept to do any work at all. The commissioners in following out this inquiry, endeavored to determine the proportion the cost of locomotive power bore to the total working cost of a railway. For the Liverpool and Manchester line it was found that this proportion was only one-fourth the gross annual charges on that line, including much town carriage of goods collected and delivered; but on the Dublin and Kingstown Railway the proportion was, at that time, nearly one-half. It was observed by the Professor, in a digression, that for the average of railways it was now determined to be about one-third. The commissioners finally assumed the cost of locomotive power to be one-third of the total expense of working a line of mixed traffic, and that to run a given number of trains per day, a certain number of engines must be provided; it was then calculated that £1750 a year would be the cost of each engine to work about from 25,000 to 30,000 miles annually, and then they computed the amount of gross receipts necessary to cover those expenses and interest of capital. This was working backwards, to ascertain whether it is justifiable to make a railway at all in certain districts. The result of the commissioners' calculations were, that, supposing there went only two trains daily throughout a given line, the average load of each train ought to consist of either fifty tons of goods, or eighty passengers, or a mixed load of twenty-five tons of goods and forty passengers, or, in that proportion, in order to justify a line being made—the average charge for passengers being assumed each 1¼*d.*, or for goods 2*d.* per ton per mile, which, it may be observed, is scarcely the half of the average rates of charge on the principal English railways. Mr. Vignoles observed, in conclusion, that having shown that the cost of conveyance of passengers, merchandize, minerals, &c., could be nicely calculated from the experience gained, and could be brought to the definite mileage rates before mentioned, *he thought the proper railway charge should be double the cost for working;* which, when the railways had been judiciously constructed, and without extravagance, would sufficiently remunerate

the undertakers, as such moderate principle of charging would bring the most traffic.

(To be continued.)

Great Britain Steamer.

By the politeness and favor of Mr. Guppy, the Engineer of the Company, we were permitted to inspect this celebrated vessel on Tuesday, the day previous to His Royal Highness Prince Albert's visit.

It is impossible for us, by any description we can give, to do justice to this great and noble ship. To form a true estimate of her, one must see her, go on board of her, and compare her with other vessels. Her upper deck, which is 308 feet long, and 50 wide, and flush throughout its entire length, appears to be a promenade, of which it would require some effort to march from one end to the other. From the figure-head to the taffrail is 322 feet.

Her grand saloon aft, is a noble room, 98 feet by 32, and near 8½ feet high. The fittings of this room are different from those of any other steamer we have yet seen. The style is extremely neat and chaste. About 8 feet from each side, and also in the centre line of the ship, are a row of pillars, some 10 or 12 feet apart, and opposite to each of these is a pilaster very tastefully ornamented, the intermediate spaces being panelled, so as to throw out the ornamented pilasters to the greatest advantage. At the ends and certain angles of the room, are placed mirrors, at such angles as to produce very pleasing illusions, and to have a fine effect.

Above this is the principal promenade saloon, which is decorated to correspond, and which also has a row of pillars down its centre. Ranged along its sides are seats for those who choose to lounge and sit, while the middle forms a light and spacious promenade in wet, or rough, weather.

In the fore part is another promenade cabin, or saloon, of less dimensions, being 67 by 21¾ feet, but intended, we hear, to be fitted up in a similar manner.

Beneath this, above the water-line, is the fore dining-room, which is 61 by 21¾ feet. There are 26 single bedded-rooms, and 113 double bedded.

For the accommodation of ladies there are large and commodious sitting-rooms communicating with their berths. These rooms, to the capacious size of which several berths are necessarily sacrificed, will be a great comfort to lady passengers, particularly in rough and foul weather.

We understand that the number of passengers' beds will be about 260. They might easily have made up a great many more, but have chosen to limit the number, rather than to encroach upon the comforts and pleasure of their customers, of which, indeed, they have been more prodigal than they might, with a just regard to their own profit.

The public has long been informed, that this vessel is to be driven by a propeller somewhat upon the principle of the screw. The plane

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four segments of fans, (frustrums of the screw spiral of 22 feet pitch) not plain, but twisted, so as to produce the best effect upon the water, the general plane of each being inclined in an angle to the plane of the propeller. The form, inclination, or pitch, and dimensions of the fans, we understand have been the result of long and careful experiment, made for the especial purpose of finding out the best form.

The diameter of the propeller is 16 feet, and its top will be under the water line when the vessel is loaded.

By dividing the propeller into four parts, it is calculated that the motion of the vessel will be easier, and that the water will not be so much sliced, as if there were a greater number of fans, and will hence be capable of offering more resistance.

The shaft of the propeller, which is of solid wrought-iron, 16 inches diameter, passes through a stuffing-box in the stern of the vessel, and terminates in a wheel, which is to be driven, as we understand, by a pitch chain passing over this and the great drum. This wheel is 6 feet, and the drum attached to the crank shaft of the engine is 18 feet diameter. The propeller, therefore, makes three revolutions for every revolution of the drum, or every double stroke of the engine.

The length of the stroke is 72 inches, and the diameter of each cylinder 88.

There are four cylinders, two placed on each side of the vessel, opposite, or nearly so, to each other, the opposite pairs converging towards the top in an angle of about 68 degrees. The connecting rods of each pair are attached to the same crank, and, therefore, drive the crank as one cylinder.

This plan simplifies the machinery much, and obviates a difficulty which had been conceived by some eminent steam navigation gentlemen, with regard to the simultaneous working of the cylinders in a rough sea. As designed, the four work as one pair.

It is intended to work the cylinders expansively, with an apparatus for cutting off the steam at any part of the stroke within certain limits. The intention is to cut off at one-fourth, and expand the other three-fourths. The computation is, that when the cut off is at half-stroke, each cylinder will do the duty of 250 horses, the steam in the boiler being 6 lbs. above the atmosphere. The engines are, therefore, collectively, of 1000 horse-power.

The boiler is 34 ft. long, 32 ft. broad, and 22 ft. high, and is divided into three nearly equal compartments, each compartment forming a separate boiler, and may be all three used separately, or together. These compartments add much to its strength. The steam-pipes from each compartment unite behind the boiler, and the steam-ways, 24 inches diameter, turn round the sides to the cylinders.

The boiler is heated by 24 fires, and its plates are 7-16th inch thick. The flues recurve within the boiler, and give it something of the property of a tubular boiler.

At present merely the boiler and cylinders are put in the vessel. The framing and truss-work for the shaft, &c., are of Demerara

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Green Heart wood, and very thick wrought-iron, and present the appearance of great strength.

The rudder is 7 ft. wide, and works upon a pivot, of course, behind the propeller, two-thirds behind it and one-third before. It will, therefore, be very easily worked, and as the propeller will force the water back upon it with considerable force, it will possess great command over her motions, even at comparatively slow velocities. This is one great advantage the screw and all aft propellers have over paddles; the vessels are always more manageable with them.

At 6 lbs. per horse-power per hour, the *Great Britain* will consume 2.67 tons of coal per hour, or near 64 tons per day. To steam, therefore, for 20 days, she must carry 1,280 tons of coals. Her bunkers will contain 1,200 tons, or provision for about 19 days.

With regard to the vessel herself, she is, on all hands, allowed to possess the finest proportion, and most beautiful lines. Her neat entrance, clean run, and gracefully swelling sides, strike the eye as exceedingly well calculated for speed, steadiness of motion, and sitting well upon the water. From her great length, and apparently narrow beam, it might be expected she would be disposed to roll, but as her water line is below the swell of her sides, that will be a great check, and the probability is, that she will ride with greater safety, and be less liable to ship seas. She is calculated to average 12 knots an hour at the least, by steam, and with a good fair wind, 13 through the water. At this rate she will reach New York in 10 days.

It is intended to carry only one class of passengers, for which, as we said, every comfort and convenience are secured.

As our readers know, she is made of iron. Her plates and angle-irons, or those which would be called her ribs, are ⅝ths of an inch thick. These are trussed with immense stringing timbers at every deck and division, and strengthened by struts from the iron joists supporting the decks. The lower decks themselves consist of narrow planks stretching from side to side, of 5 inches thick. These are again strengthened by cross-iron stays, screwed to them in all possible directions beneath. In fact, every care appears to have been exhausted to ensure ample strength and stability to this magnificent vessel.

The displacement of the *Great Britain* is about 3,200 tons. Her power, therefore, is one horse to 3.2 tons, which is a high proportion, especially for a vessel of her tonnage. Taking, consequently, into account her tonnage and power, they are warranted in calculating upon an unusually high speed.

Her engines and machinery weigh about 600 tons, and the total quantity of iron used in her, is 1,500 tons. The greatest care has been used to have none but materials, whether iron, or wood, of the very best quality.

She has 6 masts, 4 of which carry fore and aft sails only, and the main-mast, which is 75 feet high above the deck, will have an immense spread of square and studding sails.

She has 5 water-tight bulkheads, all reaching above the water-line, but some of them much higher. Her funnel is 39 ft. high, and 8 ft. diameter.

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£100,000. The weight of the main-iron shaft is 16 tons, the largest ever constructed. It was manufactured at the Mersey Iron Works. Her boiler will contain about 200 tons of water; and her pumps, worked by machinery, will be able to throw off 7,000 gallons of water a minute.

At the time we were at Bristol, we had an opportunity of going over the Company's work-shops, and were both surprised and pleased to observe the unusually fine manner in which they turn out their work—it is a credit to Bristol.

Railway Magazine.

The Steam Excavating Machine.

We have already had the pleasure of introducing this important machine to the public, and we now avail ourselves of the opportunity of giving some further account of it. As is well known, it is of American invention: and this individual machine was imported from the United States, after having been employed on a railway there for the purpose of testing its capabilities in this country. It is now at work on the Eastern Counties Railway, about 20 mile from London, and is exciting much attention. In its present state, the machine is rather complicated, but it is susceptible of great improvement; and we have no doubt that any machines manufactured in this country will be much simplified. For this purpose it cannot be in better hands, the management of the patent being entrusted to Mr. John Braithwaite, the engineer, whose mechanical attainments are well known to the public, and who is well qualified to turn a machine of this kind to the best account.

The accompanying engraving* is a perspective view of the machine when at work, and it will be seen by it, that one man, the engine-tender, stands behind, to regulate the performance of the engine, and another man in front, to regulate the motion of the scoops, and to turn the jib, or crane, to the right or left, as may be required. By the aid of this jib, the scoop is enabled to take a sweep of 30 feet, and clear away obstructions before it to the height of about 14 feet.

The cubic content of the scoop is 1½ yard, and it lifts about 1¼ cubic yard, two of which is about a wagon load of 2½ cubic yards. If the wagons were brought up as fast as the machine could supply them, it would fill 30 per hour. During the day we inspected the machine, it loaded 26 wagons of 2½ cubic yards each within the hour; and at another performance, it filled 103 cars in 5½ hours. By these trials, the duty of the machine appeared to be, upon an average, 20 wagons, or 50 yards, per hour, or 500 yards per day. This quantity does not appear to be more than half the duty of the machine, as detailed in a report before us, emanating from a committee of managers of the American Institute, New York, especially appointed to examine the machine. The committee state—

* See engraving in this Journal, page 324, vol. v.

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"The excavator has been employed for three years upon the Western Railroad, and other places, and that this test showed an immense saving of expense. It is calculated to do the work of 150 men, and will fill cars as fast as they can be presented to receive their loads. Allowing for stoppages, one minute may be given as the average for filling a car of 1½ cubic yard. The interest for the cost of the machine, wear and tear, men's wages, fuel and oil, 13½ dollars, (about 2*l.* 16*s.*) but to cover the contingencies, say 20 dollars."

There is also another report, showing the daily performance of two machines employed for two months, in almost constant work, at Brooklyn, New York, during which period the two machines worked collectively 881 hours, and excavated and loaded 92,593 cubic yards of earth, equal to 105 cubic yards per hour, or 1080 cubic yards per day. The machines worked during the above period, upon an average, nearly ten hours per day, which is equal to the working hours of a man. The quantity which one navigator can remove, or "get and fill," in one day, is about ten cubic yards, or one cubic yard per hour; we have, therefore, the performance of one machine equal to 105 men, according to the statements of the American engineers.

We will now proceed to examine the comparative cost of working by the machine and manual labor. For this purpose we must calculate the power of the engine, which is called a 10 horse engine, but on account of the high pressure at which the steam is worked, it will be found equal to 34 horse effective piston power. The following are the particulars of the engine :

Diameter of cylinder 9 inches = 63.6 square inches.
Length of stroke, 1 foot; number of strokes per minute, 100 to 110 —say 200 feet per minute.
Pressure of steam, 90 to 100 lbs, per square inch—say 90 lbs.
Fuel—coke.

Then we shall have the engine-power $= \dfrac{63.6 \times 200 \times 90}{33{,}000} = 34.7$ horse-power on the piston, which, if taken in the same proportion as low condensing engines, the nominal power of which is taken at only 7 lbs. pressure, or about half the effective piston-power, we shall have the nominal power of the engine equal to 17 horses, the consumption of which may be taken at about 10 lbs. of coal, or 8 lbs. of good coke, per horse per hour, which will give, for the consumption of the above engine, $17 \times 8 = 136$ lbs. per hour, or 12 cwt. per day of 10 hours. If we take the cost of the coke at 35*s.* per ton, delivered at the works, we shall have the cost of the fuel 21*s.*, then the cost of working the machine per day may be stated thus:—

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Oil, tallow, &c., - - - -	2 0
Engine tender, - - - -	6 0
Man on the stage, - - - -	5 0
1 laborer assisting, - - - -	3 6
Sundries, - - - - -	2 0
Cost per day, - -	40 0

This will be the cost for removing 500 cubic yards of earth, but exclusive of repairs, depreciation, interest on cost of machine. The cost of making one of the machines we estimate at 1200*l.* The cost of manual labor may be taken for "getting and filling," (see Journal vol. v, p. 187,) at 4½*d.* per cubic yard, then,

500 cubic yards at 4½*d.* = 9*l.* 7*s.* 6*d.*

We have here a difference of 7*l.* 7*s.* 6*d.* between the cost of engine and manual power; and if we make an allowance for the repairs of the machine, depreciation, interest, &c., 2*l.* per day, there will be a saving of 5*l.* 7*s.* 6*d.* We may, therefore, set down the actual cost of engine power at 2*d.* per yard, which would give 4*l.* 3*s.* 4*d.* per day, for 500 yards, thus clearly showing that the steam excavator must ultimately supersede manual labor, on account of its cost and rapidity in execution for all extensive cuttings, either for railways, canals, or docks; but if we make our calculations according to the report of the American engineers, allowing the duty of the machine to be 1050 cubic yards per day, the calculation will stand thus:—

	£	*s.*	*d.*
1050 cubic yards by manual labor at 4½*d.*	19	13	9
Deduct—working of engine per day 2*l.*, Repairs, depreciation, interest, &c., 2*l.*	4	0	0
Saving, - - -	15	13	9

By this calculation the cost of excavation is not quite 1*d.* per yard.*

Civ. Eng. & Arch. Journ.

Woolen Factory for Turkey.

Mr. Fairbairn exhibited a model, showing the plans, sections, and architectural elevation of a Woolen Factory, to be constructed of cast and wrought iron, near the town of Izmet (Turkey) for the Sublime Porte.

Mr. Fairbairn said that, in 1839, he visited Constantinople under the instructions of the late Sultan Mahomed, and reported upon nearly all the government works. Their extension was checked by the death of that prince, but the present Sultan was disposed to carry

* The above article is accompanied by letters from Mr. Whistler, the chief, and Mr. Swift, a resident, engineer, on the Western Railroad, in Massachusetts, during its construction, who speak very favorably of the actual working of these machines, in some heavy earth cuttings, on that railway, *during three years.*

Mr. Swift states, that upon one of the sections, "it excavated 19,000 cubic yards (of sand and gravel) in twenty-five working days, and 1000 yards per day were excavated for several days in succession."—Com. Pub.

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them into effect, and, by his orders, Mr. Ohanes Dadian had arrived in England, in furtherance of the plans for ameliorating the state of the Turkish community, by introducing useful arts and manufactures, in which he was aided by his Excellency Ali Effindi, the ambassador to the court of England, and the consul-general, Mr. Edward Zohrab. Almost all the houses, and many of the public buildings, in Turkey, being constructed of timber, destructive fires were frequent. In many parts of the country the common building materials were expensive; iron had, therefore, been resorted to for construction, and Mr. Fairbairn had already sent over an iron house for a corn-mill, 50 ft. long, 25 ft. wide, of three stories in height, and with an iron roof. It was finished in 1840, and erected at Constantinople in the succeeding year. The success of this attempt induced a second order, which was for an extensive woolen factory, to be composed entirely of cast-iron plates, the interior being formed throughout of brick arches, upon cast-iron columns and bearers, with an iron roof. He then described in detail, the construction of the different parts of the building, and the machinery, which would be driven by a fall of water of 25 ft. in height, of the computed average power of 180 horses. Several ingenious devices were described for preventing any objectionable effects from the high conducting power of the metal. The piers between the windows were hollow, so as to admit a current of air through during the hot season; and the iron roofs were so arranged as to have beneath them a coating of plaster, to serve as a non-conducting substance. The two principal rooms were described to be 272 ft. long, 40 ft. wide, and 20 ft. high; and 280 ft. long, 20 ft. wide, and 20 ft. high; with a great number of other rooms, for the several processes in the manufacture of coarse woolen cloths, for the counting-houses, and departments of the directors, and for the reception of the sultan, &c. The area of the enclosed surface, including the court-yard and buildings, was nearly 3 acres, or 110,621 square feet.

The floor surface in the basement rooms = 16,480 square feet. Ditto in the upper rooms = 54,616 square feet. Ibid.

Legal Decision regarding Well-Sinking.

In the Court of Exchequer Chamber in Error, on Wednesday, May 19, a judgment of considerable importance was pronounced by Lord Chief Justice Tindal, in the case of "Acton *vs.* Blundell." Within twenty years before the commencement of the action, the plaintiff had sunk a well, and the water which it collected was sufficient to work his mill; but in 1837, the defendant dug a coal-pit three-quarters of a mile distant, which, eventually, drained the well dry, and, therefore, an action was brought to recover compensation. On the trial, the judge told the jury, that if the defendant had dug the pit in the manner which was usual in working and winding a mine, he was justified by law in what he had done; and the jury found for the defendant. A bill of exceptions to this charge was presented, which

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had, subsequently, been argued, but the Court now decided that the summing up was correct. The Court were of opinion that the case should be decided on the principle of the rule which gave to the owner of the soil every thing under the surface of it; and that if the plaintiff had suffered loss by the exercise of the defendant's rights, it was a loss which was *damnosum non injuriosum*, and for which no action could be maintained. The Court, therefore, unanimously gave judgment for the defendant.

Ibid.

On a New Application of Railways. By ELLWOOD MORRIS, C. E.

It is well known that prior to the introduction of the modern railway system, cities were chiefly furnished with provisions, from a space covered by the revolution of a very limited radius, whose length was determined by the distance which horses could travel within a few hours; while but very moderate supplies, indeed, were ever drawn from a greater distance than a day's drive.

An immediate result of the greatly augmented speed of travel, consequent upon the construction of any modern railway leading from a city into the interior of the country, is a direct and considerable extension of the surface, capable of becoming with advantage, *tributary to the market of that city.*

The large augmentation of the surface of production, tributary to any market consequent upon a diminished cost and increased speed of transport, must, inevitably, have an effect upon the value of provisions there, and it will follow, hence, that whenever the railway system shall be properly availed of, for the supply of our cities, the selling prices of country produce in their markets *must fall*, and their numerous inhabitants be thereby benefitted.

This is but another phase of the important economical revolution which the great iron roads of modern days are gradually producing in all that is, in any way, dependent upon the cost, or time, of carriage.

Upon the European railways the highest advantages seem to have been derived from the facilities they furnish for the cheap and easy carriage, from great interior distances, of live stock, and other provisions, destined for the supply of the overgrown communities there assembled in the great cities.

Even in our own country their influence, in the aspect referred to, is beginning to be strongly, as well as beneficially, felt, and one railroad corporation, at least, has profited considerably by the establishment of a market train, regularly drawn, like other freight, by locomotive steam power.

We refer to the Camden and Amboy Railroad Company, the directors of which, in their elaborate report of 1840, upon the completion of their works, describe the success that has attended the establishment of a regular market train upon their railway, which has been the

York, a large district of country, practically inaccessible before.

In the report referred to, at page 11, we find the following statement:—

"Two years since, at the request of some market people in New Jersey, a line, called *the pea line*, with two cars, was occasionally started from Camden to New York, with no other view, or expectation, than the accommodation of a very useful and respectable class of men. This line has steadily increased until it has become profitable beyond all expectation. During the past year it has been running daily, sometimes taking with it as many as sixteen cars, laden, at the appropriate season, with peas, peaches, potatoes, asparagus, cabbages, live stock, and upon one occasion, (as incredible as it may seem,) *thirty tons of green corn!*"

The European railroads have been found extremely beneficial in the transportation of live stock, and other provisions, to the great cities, which have thus been enabled to draw their supplies from a much larger surface of country, and, consequently, at a smaller price.

Since the completion of the Baltimore and Ohio Railroad to Cumberland, extravagantly high prices can no longer be commanded for agricultural products on sale in the Baltimore markets; thus with the article of *butter*, it has been recently observed, that whenever it becomes unusually high, large quantities are promptly sent down by the farmers beyond Harper's Ferry, and prices fall at once.

So strong, indeed, is the influence of this railway in regulating, and keeping down to a moderate standard, the market prices of Baltimore, that it has already become a subject of complaint with those, who from the nearness of their position, have heretofore been able to hold a monopoly of the supply.

Other facts might readily be adduced, which, in connexion with the remarkable experience of the Camden and Amboy Company, would show, in a striking light, the advantages which must follow the introduction of market cars upon railways, and will, ultimately, among other results, tend to soften the prejudices still entertained, by some, against railways, as aristocratic monopolies, since, by reducing the cost of the necessaries of life to all, they will recommend themselves in the strongest manner, to a large majority of our population.

With the introduction of market trains upon railways, *provision depots* become desirable, and the first of these which has fallen under the notice of the writer, where provisions brought in railway cars are kept on sale, both wholesale and retail, is that lately erected in the city of Philadelphia, in connexion with the Columbia Railroad, and opened in June of this year, under the denomination of the *car market.*

It is this new application of railways—*to the formation of a railroad market*—that it is proposed briefly to describe.

The idea of constructing a *railway market*, having been for some time entertained by Mr. Samuel Webb, an intelligent and enterprising citizen of Philadelphia, who foresaw the advantages that must flow from the transportation of provisions by the railways centering upon

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practical details, and superintend the construction of *a car market-house,* of which he furnished the outline.

This building has accordingly been erected: it was opened to the public in June last, and promises to be very successful.

The *car market* is 200 feet long, and 40 feet wide, it fronts on Schuylkill Seventh street, north of Callowhill, its axis being parallel to the State Railroad leading to Columbia, and 130 feet distant from the southern sideling.

In consequence of the position of the building, it was necessary to enter it through the north flank by reversed curves, with a short tangent between: this is effected by turning out of the Columbia Railway to the right, upon a curve of 80 feet radius, and 51½° deflection, into a tangent running off obliquely at that angle; thence by this tangent 90 feet, and then by another curve of 80 feet radius, and 51½° deflection, turning to the left we curve into the axis of the market-house.

Through the centre of this building longitudinally, from end to end, a straight track of railway is laid, and to enable the empty cars to pass out without interference, a return track is provided, which, by a radius of 48 feet turning 128½° of curvature, re-enters the oblique tangent before mentioned.

All of these curves are laid with a common railway superstructure, and, though their radii are so very limited, they, nevertheless, answer their purpose satisfactorily.

The writer will here observe in passing, that for the ordinary entrance tracks of depots, a common railway superstructure, where all the wheels run upon their treads as usual, will answer very well when curved upon a radius of 80 feet, and of the numerous side tracks recently laid here, to accommodate the coal trade descending the Reading Railway, nearly all the curves are ordinary railroad tracks, and in some of them radii of curvature of less than 80 feet, have been adopted without inconvenience.

The car market is near 37 feet wide in the clear, and the stalls are made to project out 8 feet, at every 16 feet lineal of the walls, forming recesses between, and leaving a central promenade of 21 feet wide, entirely unincumbered, except by the pillars which carry the second floor.

This arrangement allows ample space for purchasers, even when the central railway is filled with cars, and by means of the projecting stalls, furnishes a great development of stall surface, for the exposure of provisions on sale.

The building is of stone, two stories high, and the second floor is destined, in the course of time, to be also used for the sale of the lighter articles of marketing, which, brought to the market in cars, will then be elevated to the next story, by some convenient means.

Such is the outline of an enterprize which will probably form a prototype for others on a more extended scale, *since, the idea acted upon, seems to be a sound one, and must, eventually, have a very*

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important effect upon the provisioning of those cities, which, by their railways, command the interior country.

Amer. Railroad Journal.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Cost of Transportation on Railroads. By Charles Ellet, Jr., C.E.

(Continued from Vol. IV, page 367.)

The importance of ascertaining the expense of transportation on railroads, to a large portion of the population of this country, has led to many discussions, and many inquiries, with a view to its determination. No general method has, however, yet been produced, by which it can be ascertained with any tolerable degree of accuracy. The difficulty appears to have arisen, in a great measure, from the fact, that these expenses consist in a variety of elements, which increase and diminish in value by different laws, and at rates which depend on the combinations of these elements in each particular case. It has, also, to some extent, grown out of the fact, that during the progress of this system, every year has produced some new work of improvement, which has supplied new data to calculators—and, unfortunately, data which have preceded the effect of the two greatest causes of expenditure—the destruction consequent on use, and natural decay. Without referring to another difficulty—the extravagant estimates of the friends of particular projects, and, sometimes, the gross misrepresentations of the enemies of others—we see that the subject is much too complicated to be unraveled without close study, and mature reflection. To make a general solution, we have, obviously, to allow for differences of grade, differences of tonnage, differences between the amounts of travel, and have due regard to the length, and even the age of the improvement.

Now, to attempt to go through this whole subject, and produce and analyze the data on which are founded all my conclusions, would require much more labor, than I have a disposition, at this time, to appropriate to the question. What I now propose to do, is again to point out the LAW which governs railroad expenditures, and to fix, with greater accuracy, the values of the constant coefficients than was practicable when I first offered the formula which are here repeated.

It is my intention to submit, in the first place, the law which governs the expenditures on a *new road*, and attempt to offer a reasonable explanation, and a just estimate, of the difference between the expenses incident to a new road, and an old one. If my method be true, the reasons, and the values which I assign for this difference, must be obviously just. The general law must first satisfy the mind, and the rate of increase, in passing from a new to an old road, must likewise be rational and convincing. If, after this preparatory evidence, I bring forward a certain new road of great length, and show that the calculated cost corresponds well with the actual result, it will *certainly* be a strong confirmation of the general correctness of the method. But still, for a prudent man proposing to risk his fortune, this alone ought not to be sufficient. This particular example might be selected be-

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right, therefore, to call on me to produce a *short* road, and show that the results still correspond with my calculation. His intellect might not yet be fully satisfied; it would be fair for him to call for another example, in which the trade and travel were both unusually great, in order to be assured that the method is applicable to works of that character also; and, even after finding this result to be confirmatory of the method, extreme prudence would dictate an additional application to another road with very small trade.

All this appearing satisfactory, he could not well retain a doubt; but, when men stake their fortunes, and the comfort and indulgence of their families on the issue, they have a right—they are bound—to exercise great circumspection. Such a party might, therefore, well call for an application of the method to an *old road*—or to one that has arrived at maturity, at least,—in order to see whether his investment is likely to be permanently good.

If this doubt be also satisfied; if he finds that the application may be safely made to a road of this description; if, in addition, it is made to one of this sort with a great trade—next, to one with a small trade—then to one with great travel and no tonnage; afterward to a long one, and, finally, to a short one; to some roads with light, and to others with heavy grades—and, if he find that it gives consistent results in all these varied applications—as a reasonable, and as an intelligent man, he will be compelled to admit, that the method is in accordance with THE LAW, and that its results are the TRUTH.

It is such testimony that I propose to offer the reader, and I solicit his attention in order that he may judge fairly of my consistency—for consistency is a test of truth.

The following propositions are what I designate as Laws:—

I. The cost of motive power, with engines of the same class, is proportional to the distance which the engines run. The cost per mile is nearly the same on roads of all grades—the difference in expense on roads with different grades, consists not essentially in variations of the cost *per mile run*, but in variations of the number of miles which must be performed to do the same duty.

II. The repairs of the road, with equal trade, are proportional to its length; that is to say, *cæteris paribus*, it costs twice as much to keep up a road 200 miles long, as it does to maintain one in the same condition, of which the length is 100 miles; just as it costs twice as much to run engines 200,000 miles, as it would to run the same class of engines 100,000 miles.

III. The repairs of cars are proportional to the number of tons conveyed, and to the distance to which they are conveyed. It costs twice as much to repair cars which run two millions, as it does those which run one million of miles per annum. Again, it costs twice as much to repair cars which convey 20,000 tons a given distance, as it does those which convey 10,000 tons the same distance. The same principle applies equally to the conveyance of passengers; it applies also to accidents, incidentals, and contingencies—for these things increase with, and are proportional to, the increase of business.

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These may appear like self-evident truths, and they are, in fact, so glaring that they scarcely appear to have been looked on at all. The custom now is to regard the expense of cars as proportional to the distance the *engine* runs. It is here made proportional to the distance the *cars* run. It is customary also to consider the repairs of the road as proportional to the distance traveled by the engine—whereas it is only proportional to the length of the road.

These are simple principles, and such as cannot well be doubted, or denied. It remains to state the values of the constants.

Repairs of Roads.

The repairs of a railroad, I have stated, must be divided into two classes—those which are dependent on, and those which are independent of, the amount of the tonnage. Of the first division, the wear of iron depends entirely on the use, and the wear of the wood, but partially on the use. The rotting of timber, the cleaning out of ditches, the repairs of culverts, embankments, &c., are independent of the trade. But these items are not independent of *time;* the expenses of repairs increase but little until the wood in the sills, ties and rails, begins to decay, and require removal, when they usually soon attain their maximum, and afterward diminish, until they reach a second minimum.

The following table exhibits the cost of repairs on six of the most successful roads in this country, which I have purposely selected from different sections. The table embraces three roads of each of the two great classes—three wooden superstructures with plate rails, and three iron roads with T or H patterns.

By casting the eye down the columns, the progressive increase of expenses will be easily recognized. It must be borne in mind, however, that these numbers do not include the renewal of the iron—an item always charged to "extraordinary repairs," or "permanent improvements"—as though iron rails were ever permanent, or their destruction extraordinary. Eventually, the cost of the new iron passes into capital stock, or funded debt.

TABLE showing the Increase of the Cost of Repairs of Railroads.

Year.	Permanent Roads—T Rail.			Wooden Roads—Flat Bars.		
	Boston & Lowell.	Boston & Provid'ce.	Boston & Worcester	Utica & Schenec'y.	Petersburg Road.	S. Carolina Road.
1836					251	870*
1837	546	285	206	354	664	880
1838	611	411	281	330	542	1040
1839	731	209	405	450	539	982
1840	816	334	830	618	794	592
1841	1200	597	784	837	857	547
1842	1350	514	903	935		503
1843						375

I may add the following notes of the cost of motive power per mile traveled by the engines, which are extracted from documents that were not in my possession when I first stated the cost per mile for passenger engines at 25 cents, and of freight engines at 30 cents.

* Finished in 1833, when the expenses were very low.

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TABLE showing the Cost of Locomotive Power for 1842.

Name of Road.	Miles run.	Expense.	Cost per mile.	Year	Remarks.
Boston and Providence.	35,031	$ 11,399	$32\frac{1}{2}$	1842	Freight engines.
Boston and Providence.	77,774	23,352	30	1842	Passenger engines.
Western Road.	397,295	84,165	$21\frac{1}{7}$	1842	Exclusive of wages.
Western Road.	397,295	115,000	30	1842	Wages included.
Utica and Schenectady.	155,828	33,454	$21\frac{1}{2}$	1841	Exclusive of new engines.
Utica and Schenectady.	155,828	52,268	$33\frac{6}{10}$	1841	Including new engines.
Reading Road.	83,717	17,443	$20\frac{8}{10}$	1841	With new engines.
Reading Road.	198,055	49,800	$25\frac{1}{4}$	1842	New, but heavier, engines.

This table entirely confirms the previous estimate (vol. iv, p. 307.) Another table in my possession (derived from reports of 1842) gives for the average value of repairs of locomotives, 7 cents per mile run; my impression is, however, that this item is worth not less than 8 cents, and that future observation will maintain it, for engines that are not fresh from the factory, at about that average.

We may now pass to the method and the rule which I propose for computing the aggregate annual expenses of a road. In the first numberof this investigation, I proposed a formula which was published in this journal, for determining the value of these expenses—stating, however, that there was no line in the country which had yet exhibited results as favorable as those expressed by that formula. The present paper is intended to show these expenses *as they are;* the same formula is used though the constants are modified to suit the actual condition of the system.

For new Roads.

The aggregate annual charges on *new roads** are made up of the following items, viz.:—

For every mile traveled by the engines, 24 cents; for every ton conveyed one mile, 9 mills; for every passenger conveyed one mile, 7 mills; and for every mile in length of the road, 300 dollars, a fact which is expressed by the formula,

$$\frac{24}{100}N+\frac{9}{1000}T+\frac{7}{1000}P+300h.$$

Now, new engines consume as much, or nearly as much, fuel and oil as those which have been used; and they require the same number of enginemen and firemen. The only reduction in the cost of their maintenance, consists in the item of repairs. The bill for repairs for the first year or two, is only about one-half its mean value; and as the average cost of repairs is about 7 cents per mile run, the aggregate cost per mile run on a road which has passed its fourth year, should be $27\frac{1}{2}$ cents, instead of 24 cents.

The *timber* in the superstructure is worth, on the average, from 1000 to 1500 dollars per mile, and lasts from 5 to 7 years. The decay of timber in roads of mature age, is, therefore, about $200 per mile—so that ordinary repairs on such roads will be about $500 per mile.

The wear of cars after the road has been a few years in operation, is equivalent to about $4\frac{1}{2}$ mills per ton per mile; and on a new road

* I designate as *new*, roads less than five years old.

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it is scarcely appreciable. The difference between the perceptible injury to the road and cars, on a new and old road, is about 5 mills per ton per mile. The rule then is,—

For old Roads.

For every mile traveled by the engines, (passenger engines 25 and freight engines 30 cents,) an average of 27½ cents; for every ton conveyed one mile, 14 mills; for every passenger conveyed one mile, 7 mills; and for every mile of road, $ 500.

If the principles and the values here offered be correct, they will stand the test of trial, and in order to make the test the strongest possible, I will add, in a subsequent paper, an estimate of the probable results on a road in active operation, and the subject of much speculation at the present time, the correctness of which estimate can be verified at the end of the year.

This rule, if applied to the business of a line in activity, will give only those expenses which are usually denominated "ordinary expenses." In order to arrive at the *true cost* of maintenance we have to add, of course, the extraordinary expenses, which we can likewise estimate with some, though not very great, accuracy, by data now supplied by the improvements of the country.

Application of the formula to Active Works.

I shall apply this method of computation, in the first place, to a railroad in Georgia, 147½ miles long, with easy grades and little business; next, to one in Massachusetts, 156 miles long, with grades of more than 80 feet to the mile, on which the engines travel nearly four hundred thousand miles per annum, and where the trade and travel are both great; I will then apply it to a short road in the State of New York, which carries no tonnage at all, but which derives its revenue entirely from passengers, and which has moderate grades, and a moderate business; next, I will make the application to a road in Maryland 70 miles long, with grades of 84 feet, and which derives two-thirds of its revenue from tonnage. Finally, I will apply it to a road in Pennsylvania 56 miles long, with favorable grades and moderate business—and again to the same road the next year, when extended 38 miles further, and having an increase of business.

The following table gives the length, grades and business of these roads; and, in the two last columns, are placed, side by side, the actual and calculated expenses.

***TABLE** exhibiting the actual and computed cost of maintaining New Roads, calculated from the formula,*

$$\frac{24}{100}N + \frac{9}{1000}T + \frac{7}{1000}P + 300h.$$

Name of Road.	Length. miles.	G'de. in ft.	M. traveled by engines.	Thro' tonn'e.	Thro' travel.	Expenses.	Calculat'd expenses.	Year.
Georgia Road,	147½	37	152,873	10,000	12,000	$109,619	$106,605	1842
Western Road,	156	83	397,295	40,000	53,000	256,619	256,18[illegible]	1842
Syracuse and Utica,	53		84,000		70,769	62,325	62,315	1842
Baltim'e & Susqueh'a.	70	84	128,349	23,000	16,500	75,224	74,379	1842
Reading Road,	56	19	83,717	24,000	31,453	62,635	61,318	1841
Reading Road,	94		198,055	65,000	33,720	138,900	152,911	1842

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The roads named in this table are all those which have been completed less than four years, of which I have been able to procure the trade and travel, aggregate expenses, and distance run by the locomotive engines for the year 1842. In some of these I have been compelled to deduce the through tonnage from the receipts and prices —the reports giving only the aggregate tonnage ;—in general the through travel is given with precision.

The agreement between the actual and calculated results in this table, is most remarkable, and exhibits a degree of uniformity in the administration of the lines, which could not have been anticipated. Indeed it is most probably because the roads are so new that the agreement is so perfect. When they begin to feel the effects of time and use, they will give way unequally, and exhibit much wider deviations from the rule. This fact is exemplified in the following table, which exhibits the results of experience on ten important railroads, selected from different sections of the country. The roads in this table vary in length from 14 miles to 136 miles; in grades from 10 ft. per mile, to 83 ft. per mile; in freight from nothing to 94,000 tons; in travel from 7,000 to 180,000 passengers; and in expenses from 30,000 to 225,000 dollars per annum.

***TABLE** exhibiting the actual and computed cost of maintaining roads which have been completed more than four years, calculated by the formula,*

$$\frac{27.5}{100}N + \frac{14}{1000}T + \frac{7}{1000}P + 500h.$$

Name of Roads.	Year.	L'gth in miles.	G'de. in feet.	Miles run.	Thr'gh tonna'e	Thr'gh travel.	Actual expenses.	Calculat'd expenses.
Boston and Providence,	1842	42	38	120,000	21,200	117,129	$101,596	$100,897
Baltim'e and Washing'n,	1841-2	30½		91,428	27,369	114,260	73,684	76,166
Petersburg Road, -	1842	61	30	131,160	22,000	16,000	96,398	92,489
Nashua and Lowell,	1841	14	10	44,040	28,663	85,737	30,708	33,131
Baltimore and Ohio,	1842	82	82½	299,617	44,477	34,380	220,135	192,925
Portsmouth & Roanoke,	1842	79		96,000	5,975	7,662	73,845	76,703
Boston and Lowell,	1842	26	10	143,607	93,927	179,819	131,012	119,409
Philadelp'a & Columb a,	1842	82	45	261,844			116,000	112,979
S. Carolina Road,	1842	136	35	260,324	27,000	24,000	225,743	213,945
Boston and Worcester,	1842	44½	42	241,319	61,911	165,720	168,509	176,815
Utica and Schenectady,	1841-2	78		152,764		114,527	154,436	143,542

[NOTE.—The miles run on the *Petersburg Road* are assumed to be the same as in 1841; the tonnage is estimated from the tonnage of 1841, with an allowance for the increased receipts. The results on the *Baltimore and Ohio Road* for 1841 are preferred, because those of 1842 are complicated by the extension of the line to Cumberland. The report of the *Philadelphia and Columbia Road* contains only the expenses of motive power and repairs; the freight and passengers are conveyed by other parties; we have, therefore, in the formula to make P=0 and T=0, for this case. The tonnage and travel on the *South Carolina Road* are deduced from the printed reports. The actual charges on some of the lines will be seen to differ from other published statements; this will be found to arise from the fact that

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power on branch roads, which are rejected in this comparison.]

Here is presented a list of eleven roads, situated in different sections of the country, and offering every variety of length, grade and business that could be desired, in order to put the formula to the severest test. The greatest difference which is exhibited in the whole list between the actual annual cost of maintenance, and the estimated cost, *is* 12 *per cent.;* certainly no closer agreement could be expected since the actual expenditures fluctuate to that extent—and, perhaps through wider limits—from year to year; the removals of decayed timber, and various contingencies, being found much more extensive some years than others. In looking over the list I am able to account in almost every instance, for these departures from the formula, ... my personal knowledge of the situation of the line. It will probably be seen on some future occasion, that those roads which now exhibit expenses above the formula, will fall below it for other years—a remark which is applicable to the Boston and Lowell, Baltimore and Ohio, and South Carolina Roads.

It is no part of my object to flatter the expectations of railroad companies, but to exhibit to them and the public the truth; to those companies whose works are now new, and who *seem* to be making money, I would suggest the timely formation of a contingent fund to prepare them for a contingency which will as surely reach them as the next new year. It is bad policy to divide the *annual expenses* as if they were real profits; the money that is earned at the expense of the rails, cars, and machinery, should be hoarded to replace those things, and not distributed, as if they were to last forever. It can be shown that every company should annually store away, in times of prosperity, while their work is new, at least 6 cents for every mile travelled by their engines, 1 cent for every ton conveyed one mile, and 200 dollars for every mile of road, to replace decayed materials and injured iron and machinery. If their profits will not permit this reservation, then the prudent man will avoid their stock; and the company should cut down their expenses to the limit assigned by the trade. Where these expenses do not consist of interest on debt, ... retrenchment is almost always possible.

In the first of these tables the Reading Railroad appears to escape the application of the rule; the calculated expenses exceeding the actual charges, as stated by the company, some $14,000, or about 10 per cent. There has probably been a division made between the current and contingent expenses on this line; indeed, on inspecting the published exhibit, I find that the whole sum set down for *timber* used in repairing 94 miles of road, including rails, sills, &c., is just $2,431. Now, I know personally, that twice that sum would not pay for the timber required for repairing the bridges alone; the bridge account last year must have amounted to more than $12,000, and seems not to be included in the published statement. This sum being added to the published total, brings the year's expenses up to $151,000, or within 1½ per ct. of the formula. Perhaps the company regard the loss of a bridge as so extraordinary an occurrence, that it can never take place again; but

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their report already points to another which is found to be "less permanent than the rest;" and time will show that no part of railway superstructures will long remain permanent under the action of heavy engines and their trains. Besides there will be freshets, and tornadoes, and fires; and on a road which has a great many bridges constructed of perishable materials, and which is travelled by 25 or 30 locomotives every day, or about 10,000 trains a year—with engines using pine wood for fuel—many accidents must be expected. One bridge per annum is a small allowance for the average loss; and if the bridges happen to be fortunate, there will be rotten sills, or crushed iron, enough to compensate for the difference.

We perceive then that the formula applies also to this road; and I will now insert a table exhibiting its application to all the roads of which I have been able to obtain the amount of trade, and annex a column showing the per centage of error for each; not having the number of miles run by passenger and freight engines separately in every instance, I make use of the mean value 27½ cents per mile run.

TABLE.

Name of Road.	Year.	L'th.	G'ds.	Miles run.	Through tonnage.	Through travel.	Actual expenses.	Calculated expenses.	Err'r pr.ct.
Georgia Road,	1842	147½	37	152,873	10,000	12,000	$ 109,819	$ 106,605	−2¾
Western Road,	1842	156	83	397,295	40,000	53,000	256,619	256,187	0
Syracuse and Utica,	1842	53		84,000		70,769	62,325	62,315	0
Baltimore and Susque'a.,	1842	70	84	128,349	23,000	16,500	75,224	74,379	−1
Reading Road,	1841	56	19	83,717	24,000	31,453	62,635	61,318	−2
Reading Road,	1842	94	35	198,055	65,000	33,720	151,000	152,911	+1¼
Boston and Providence,	1842	42	38	120,000	21,200	117,129	101,596	100,902	−⅜
Baltim. and Washington,	1841–2	30½		91,428	27,369	114,260	73,684	76,193	+3½
Petersburg Road,	1842	61	30	131,160	22,000	16,000	96,398	92,310	−4
Nashua and Lowell,	1842	14	10	44,040	28,663	85,737	30,708	33,131	+8
Baltimore and Ohio,	1841	82	82½	299,617	44,477	34,380	220,135	192,925	−12
Portsmo'th and Roanoke,	1842	79		96,000	5,975	7,662	73,345	76,703	+5
Boston and Lowell,	1842	26	10	143,607	93,927	179,819	131,012	119,409	−9
South Carolina Road,	1842	136	35	260,324	27,000	24,000	225,743	213,945	−5
Boston and Worcester,	1842	44½	42	241,319	61,911	165,720	168,509	176,831	+6
Utica and Schenectady,	1841–2	78		152,746		114,527	154,436	142,542	−8
Philada. and Columbia,	1842	82	45	261,744			116,000	112,979	−2¼
					Tons 1 mile.	Pas. 1 mile.			
Aggregate,		1251		2,886,292	33,360,560	57,726,906	$ 2,109,188	$ 2,068,165	

One word more in reference to this table. I offer here a list of 17 railroads, presenting almost every conceivable variety of length, grade, and character. It is not a *selected* table, but contains the results of one year's operations on *every* road, without exception, concerning which I have been able to obtain the necessary data—materials which have only been procured by dint of great exertion. It will be seen that the management upon these various lines is very nearly uniform, and that they are *all* obedient to the *law*. The greatest departure from the formula is 12 per cent.

Now, this list embraces roads which are situated in every one of the sea-board States from Maine to Georgia; the aggregate length of line exhibited is 1251 miles; the engines traverse annually a space of 2,886,300 miles, and they carry no less than 33,360,560 tons, and 57,726,906 passengers one mile. The aggregate ordinary expense of maintaining this length of line, and accommodating this amount of tonnage, is actually $2,109,188 annually, and the calculated expense $2,068,165. The difference between the calculation and the fact is $41,023, or less than two per cent.

I conceive, therefore, that I have authority sufficient for announcing this formula as expressing the law of railroad expenses—a law to which all the roads in the country are obedient. If stronger evidence of its correctness could be offered, I know not in what it would consist. It is in vain to urge here that a certain road has peculiarly steep, or peculiarly light, grades, which should exempt it from the application of the rule. The formula which I announce, accounts for these differences. When the grades are easy, the engines make fewer miles, and the rule looks only to the miles.

There is yet another point of great importance connected with this subject, which ought not to be overlooked, viz., the "extraordinary expenses." It is the custom among too many of the parties interested in the railroads of this country, to look upon the suggestion that iron may be worn out, as a thing so chimerical and visionary, as to be entirely unworthy of their sober thoughts. In the course of a few years they are surprised by the fact—the certainty—that money must be raised, and that their iron *must be* renewed. Instead of being warned by experience, and commencing immediately the work of retrenchment, and the provision of a surplus fund to meet the recurrence of the contingency, they look upon it as extraordinary in the extreme—a sheer accident, which cannot occur again, or which can be warded off by a heavier iron. Experience and common sense teach that heavier iron will be attended with heavier expense; but they have *not yet* taught that the wear will be less. A heavier rail will longer resist a given trade; but will each dollar put into the heavy rail go farther? This, however, is a subject which must be reserved for a future number of the Journal.

To be Continued.

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Mechanics, Physics, and Chemistry.

A notice of the occurrence of a Metallic Alloy in an unusual state of aggregation and molecular arrangement. By Robert Mallet, Esq., M.R.I.A.

Amongst the several classes of substances which chemistry at present considers as simple, the metals stand pre-eminently marked by their almost invariable possession of a nearly fixed and striking group of sensible qualities, which together constitute the well known "metallic character." Some of these, such as lustre and fusibility, are common to every metallic body; but by the occasional variation of nearly every other sensible quality of the metals, the law of continuity remains unbroken, which unites them in different directions with the other classes of material bodies. Thus opacity, which is probably mechanically destroyed in gold leaf, is lost in selenium; and so, ir this most prevalent of their properties, the metals, through tellurium, selenium, and sulphur, become translucent, and mingle with the non-metallic elements. So also their solidity, at common temperature, is lost in mercury; their great density, in sodium and potassium; their malleability, in bismuth, antimony, and arsenic; while in tellurium, the power to conduct electricity is nearly wanting; and, lastly, hydrogen, to all intents a metal in its chemical relations, yet possesses not a single physical quality in common with these, but exists as an invisible and scarcely ponderable gas.

But although *different* metals thus vary in sensible qualities, those which collectively belong to the *same* individual metal are as remarkable for their permanence.

Unless selenium be admitted to be a metal, no approach to dimorphism has hitherto been recognized in any body of the class; the only case recorded, that by Dufresnoy, of the occurrence of cast-iron in cubes and rhomboids, not having been given by him with certainty, nor since verified by other observers. Hence, any instance of such a character, or tendency towards it, is worthy of attentive consideration; and it was with this view that the author brought before the Academy the following notice of the occurrence of an alloy of copper in two states, having totally different sensible and physical qualities, while identical in chemical constitution. The alloy in question, in its original, or normal, condition, was, in fact, a species of brass; and the particular specimen presented to the Academy, was a portion of one of the brass bearings, or beds, in which the principal shaft of a large steam engine revolved.

The bearing, or bed, of a shaft (as is generally known,) consists of a hollow cylinder, generally of brass, divided in two by a plane passing through the axis; its inner surface is finely polished, and sustains the shaft, during its revolution, which is also polished; the cavity of the brass being completely filled by the shaft, which, in the present instance, was of cast-iron, and about nine inches in diameter.

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It frequently happens, notwithstanding the polish of both metallic surfaces, and the application of oil, that the friction due to their rapid passage over each other, while exposed to undue, or irregular, pressure, produces a considerable rise of temperature, and the brass becomes abraded. Its particles have no coherence, and much resemble the "bronze powder" used by painters.

In an instance, however, which some time since came under the author's notice, a different result took place. The minute particles of abraded brass, were, by the motion of the shaft, during a few hours, impacted into a cavity, at the junction of the two semi-cylinders of the bearing, where they became again a coherent mass, and when removed, presented all the external appearance of an ingot, or piece, of brass which had been poured in a state of fusion into the cavity. On more minute examination, however, the mass was found to differ much in its properties from the original brass, out of which it was formed.

The mass, or ingot, of brass, thus formed by the union of particles at a temperature which had never reached that of boiling water, and a fragment of which was presented, possessed on that side which had been in contact with the shaft, a bright polished metallic surface, like that of the original metal from which it had been formed: its other surfaces bore the impress of the cavity in which it was found. It was hard, coherent, and could be filed, or polished, like ordinary brass. It was, however, perfectly *brittle;* and when broken, the fracture, in place of possessing a sub-crystalline structure and metallic lustre, like that of the normal brass, or alloy, was nearly *black*, and of a fine grained *earthy* character, and *without any* trace of *metallic lustre*, or appearance.

Examined with a lens, some very minute pores, or cavities, are found throughout its substance, which is uniformly of a very dark brown, or nearly black, color, and devoid of all metallic character, except when cut, or filed—that is, in mineralogical language, its color is earthy black, and its streak metallic.

The author remarked that the observed cases of aggregation in solid particles, without the intervention either of a solvent, or of fusion, are extremely rare, and, as bearing upon the little understood subject of cohesive attraction, are of much interest.

The property of welding, which is possessed by all bodies, whether metallic, or not, which pass through an intermediate stage of softness, or pastyness, previous to fusion, and is not found in any substance which readily crystallizes, and hence passes *per saltum* from the solid to the liquid state by heat, forms a "frontier instance" of cohesive forces, being enabled to act in the aggregation of bodies, by only an approach to liquidity, or by a very small degree of intermobility.

Aggregation may also take place between portions of a body merely *softened* by a solvent, which is afterwards withdrawn, as in the familiar instance of India rubber, softened by naphtha for the manufacture of waterproof cloths; where the former, after being moulded, or united, in any way required, is left in its pristine condition by the evaporation of the naphtha from amongst its particles. But the cases

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presence of solvents, are so rare, that but two or three have as yet been observed. Of these the most remarkable is that recorded by Pouillet, of the gradual, but complete, adhesion of surfaces of clean plate-glass, when left to repose on each other for a considerable time. It has also been stated, that clean plates of lead, or of tin, if pressed together by a considerable force when cold, require a proportionally great force to separate them. The case presented to the Academy, therefore, is another added to these rare instances of molecular aggregation in solids, independent of solution of fusion: the author, therefore, thought it worth while to examine, with a little care, the properties, both of the original brass, and of the mass thus curiously formed from it, or, as he thenceforth called them, of the *normal,* and the *anomalous* alloy.

The normal alloy is of a bright gold color, and sub-crystalline in structure, and of great toughness; its cohesive force is equal to 21.8 tons per square inch, which is above the average strength of any of the alloys of copper and zinc, or copper and tin, as found by my experiments on the cohesive power of these alloys, published in the proceedings of the Academy, and elsewhere. The cohesive force of the anomalous alloy is only 1.43 ton per square inch, or only about one-fifteenth that of the former.

The specific gravity of the normal alloy is = 8.600; that of the anomalous only = 7.581.

On submitting both alloys to analysis, their constitution proved identical; it is as follows:—

Copper, - - -	83.523
Tin, - - -	8.833
Zinc, - - -	7.510
Lead, - - -	0.024
Loss, - - -	0.110
	100.000

Uniting the small amount of lead with the tin, and dividing by the atomic weights, the nearest approach to atomic constitution is,

Copper,	=	26.3 atoms.
Zinc,	=	2.3 "
Tin	=	1.5 "

These alloys have therefore not a strictly definite constitution, but one more nearly so than is usually found in commerce.

Both alloys are equally good conductors of electricity. The author examined their relative powers of conducting heat by the method which Despretz has employed with so much accuracy, and found that of the normal to that of the anomalous alloy as 36 : 35, numbers which are so nearly equal as to render it likely the difference is only error of experiment. He also endeavored to determine their relative specific heats, using the method of mixture, which was the only one which the small size of the metals permitted, and eliminating the errors in-

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and then cold into hot water. In this way, if,

W and t = the weight and temperature of the water,
M and t' = the weight and temperature of the metallic alloy,
m .... = the mean temperature of both,
S .... = the specific heat of the alloy,

there are two values, one where the metal is the hotter,

$$S=\frac{W(m-t)}{M(t'-m)};$$

and another where the water is the hotter body,

$$S=\frac{W(t-m)}{M(m-t')};$$

the mean of which is the specific heat of the alloy pretty exactly. The result gave the specific heat of the normal alloy = .0879, water as unity, and that of the anomalous alloy = .0848; both of which are below the specific heat assigned by Dalton to brass.

The normal alloy is malleable, flexible, ductile, and laminable. In the anomalous alloy there is an absolute negation of all these properties.

The normal alloy readily amalgamates with mercury at common temperatures; the anomalous alloy will not amalgamate with mercury even at 400° Fahrenheit.

When the anomalous alloy is heated to incipient redness in a glass tube, a minute trace of water, and of a burned organic substance probably adherent oil, are discoverable; it suffers no change, however, but a slight increase of density. The normal alloy suffers no change when so treated. The normal alloy, treated on charcoal with the blowpipe, fuses at once into a bead. On treating the anomalous alloy so, the fragment swells rapidly to more than twice its original bulk, on becoming bright red-hot; it then glows, or becomes spontaneously incandescent, in the way that hydrated oxide of chrome, and some others do, and instantly contracts to less than its original bulk, and becomes a fluid bead, which, on cooling, differs in no respect from the original alloy.

The anomalous alloy, when pulverized in an agate mortor, forms a *black powder*, devoid of all appearance of a metal; its filings also are quite *black;* while those of the normal alloy, produced by the same file, possess the usual metallic lustre. These facts, in connexion with the black color and fine earthy appearance of the fracture, bring to mind the case recorded by Sir David Brewster, of a piece of smoky quartz, the fracture of which was absolutely black, and yet was quite transparent to transmitted light, and whose blackness, he found, arose from the surfaces of fracture, consisting of a fine down of short and slender filaments of transparent and colorless quartz, the diameter of which was so small (not exceeding the one-third of the millionth part of an inch,) that they were incapable of reflecting a single ray of the strongest light. In describing this, Sir David Brewster predicted that "fractures of quartz, and other minerals, would yet be found

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which should exhibit a fine down of different colors, depending on their size."

It seems, therefore, extremely probable that the cause of the near approach to blackness in the fracture and filing of this alloy, arises from the excessive minuteness of its particles, and thus fulfils the foregoing prediction; the brownish tinge being produced by the reflexion of a little red light.*

The polish and power of reflecting light of the anomalous alloy, are not quite so great as those of the normal, but are still remarkable; and, as it seemed a matter of some interest to determine whether both reflected the same quantity, or intensity, of light at equal angles, the author endeavored to ascertain this point as respects heat, by means of Melloni's pile for the galvanometrical determination of temperature, assuming, as suggested to him by Professor MacCullagh, that what would be true of heat in this respect, would also be so of light; but from the small size of the reflecting surfaces he had at his command, he found it impossible to arrive at any trustworthy result. He is, however, inclined to believe, that both metals reflect most at a perpendicular incidence.

From the foregoing detail of the properties, in several respects so different, of this substance in its normal and anomalous states, the author thinks he is warranted in pronouncing it the first observed instance of an approach to dimorphism in a metallic alloy; and one, the mode of production and characteristics of which present several points of interest.

The conditions under which the alloy was aggregated, involved extremely minute division of the metal, great pressure in forcing the divided particles into contact, and nearly the exclusion of air. Considerable electrical disturbance may have also co-operated; such, together with induced magnetism, being the constant accompaniments of motion in heavy machinery. By re-establishing these conditions, under suitable arrangements, the author hopes to repeat the results thus accidentally first obtained, and so produce possibly dimorphous states of other metals, or their *definite* combinations.

There is but one body which occurred to the author presenting an analogy to this anomalous alloy, namely, indigo; whose fracture, it is well known, is fine earthy, and of the usual blue color, but becomes coppery, or assumes the metallic lustre on being rubbed, or burnished.

Lond. Edin. & Dub. Phil. Journ.

On Palladium—its extraction, alloys, &c. By William John Cock, Esq.†

This metal was discovered by Dr. Wollaston, in the year 1803,‡ as

* Since this paper was read, Professor Lloyd suggested to the author, the analogy between the appearance of the powder and filings of the anomalous alloy and platina mohr, and those powders obtained by reduction of other metals by hydrogen. None of these, however, are coherent, which constitutes the peculiarity in the present case.

† Communicated by the Chemical Society; having been read January 3, 1843.

‡ Dr. Wollaston's original paper on Palladium, reprinted from the Philosophical Transactions, will be found in Phil. Mag. S. 1, vol. xx, p. 163; see also vol. xv, p. 287.—Ed.

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one of the alloys of native platinum, which, for some time after this discovery, appears to have been considered the only source of palladium; and as the quantity of the latter metal so alloying the native platinum is very small, it was then considered as a very rare metal: of late years, however, the importation into this country from Brazil of gold dust, alloyed with palladium, has occasioned a much more extensive supply of this metal, as it exists in some specimens of gold dust, to the extent of 5 or 6 per cent., and in one instance (that of the gold from the Candonga mine) it constitutes the only alloy of the gold.

The operation of refining is conducted in the following manner:—The gold dust is fused in charges of about 7 lbs. troy, with its own weight of silver, and a certain quantity of nitrate of potash; the effect of this fusion is to remove all earthy matter, and the greater part of the base metals contained in the gold dust, and in the silver melted with it. The fused mixture is cast into ingot moulds, and when cooled, the flux, or scoria, (containing the oxides of the base metals, and the earthy matter, combined with the potash of the nitre) is detached. Two of the bars thus obtained are then remelted in a plumbago crucible, with such an addition of silver as will afford an alloy containing one-fourth its weight of pure gold, and which being first well stirred to insure a complete mixture, is poured through a perforated iron ladle into cold water, and thus very finely granulated; it is then ready for the process of parting. For this purpose about 25 lbs. of the granulated alloy is placed in a porcelain jar, upon a heated sand-bath, and subjected to the action of about 25 lbs. of pure nitric acid, diluted with its own bulk of water; after the action of this quantity of acid, the parting of the gold is very nearly effected; but to remove the last portions of silver, &c., about 9 or 10 lbs. of strong nitric acid is boiled upon the gold for two hours. It is then completely refined, and after being washed with hot water, is dried and melted into bars containing 15 lbs. each.

The nitrous acid gas, and the vapor of nitric acid arising during the above process, are conducted by glass pipes (connected with the covers of the jars,) into a long stone ware pipe, one end of which slopes downwards into a receiver for the condensed acid, the other end being inserted into the flue for the purpose of carrying off the uncondensed gas.

The nitrate of silver and palladium obtained as above, is carefully decanted into large pans, containing a sufficient quantity of solution of common salt to effect the precipitation (as a chloride) of the whole of the silver, the palladium and copper remaining in solution in the mother liquor, which is drawn off, and when clear is run off, together with the subsequent washings from the chloride of silver, into wooden vessels, and the metallic contents are then separated in the form of a black powder, by precipitation with sheet zinc, assisted by sulphuric acid.

The chloride of silver, when washed clean, is reduced by the addition of granulated zinc, washed on the filter with boiling water,

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From the black powder obtained as above, the palladium is extracted by resolution in nitric acid and super-saturation with ammonia, by which the oxides of palladium and copper are first precipitated, and then redissolved, while those of iron, lead, &c., remain insoluble. To the clear ammoniacal solution, muriatic acid is then added in excess, which occasions a copious precipitation of the yellow ammonio-chloride of palladium, from which, after sufficiently washing it with cold water and ignition, pure metallic palladium is obtained. The mother liquor and washings contain all the copper and some palladium, which are recovered by precipitation with iron.

Pure palladium is of a greyish-white color, rather darker than that of platinum; it is both malleable and ductile, though inferior in those qualities to pure platinum; its specific gravity is 11.3, which may be raised by hammering, or rolling, to 11.8. When perfectly pure it cannot be fused even in small quantities in ordinary blast furnaces, but may be brought into such a state of agglutination as to bear laminating, or drawing, into wire.

It may be completely fused by means of oxygen gas, and being kept some time fused, it is said to burn with the production of brilliant sparks; it is not tarnished by exposure to sulphuretted hydrogen, nor oxidated by the air at the ordinary temperature, or at a bright red heat; but it has the singular property of becoming oxidated by exposure to air at a dull red heat, the surface becoming colored in the same manner as iron or steel; and by continuing the process cautiously for some time, the metal becomes coated with a brittle crust of oxide of a brown color; this oxide is, however, reduced by a temperature very little higher than that necessary for its formation, and the surface of the metal regains its original color upon being heated to a bright red, and cooled out of contact with the air.

It is with difficulty soluble in nitric acid when pure and fused, or in a state of aggregation, but is readily so when alloyed to some extent with silver, or copper, and still more so when in the form of the black powder above referred to, in which state it is also soluble with the aid of heat in sulphuric and muriatic acids; but its proper solvent is nitro-muriatic acid, which, if it be not very much alloyed with silver, dissolves it readily.

It is, of all the metals, that which has the greatest affinity for cyanogen; and by means of cyanide of mercury, it may be separated from all its solutions.

It may be alloyed so as to be malleable with gold, silver, and copper; several of its alloys, with the two latter metals, being of great use in the arts from their hardness and elasticity, and non-liability to rust, or tarnish. When added to gold or copper, it whitens both those metals in a very great degree, about 20 per cent., being sufficient, in either case, to destroy the color of those metals.

The uses to which the alloys of palladium have been applied, are for the points of pencil-cases, for lancets for vaccination, for the graduated scales of instruments, as a substitute for gold in dental surgery,

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or for any purpose where strength and elasticity, or the property of not tarnishing, is required. Ibid.

Account of a series of experiments on the comparative strength of solid and hollow Axles. By JOHN OLIVER YORK, Assoc. Inst. C. E.

The author first describes the causes of fracture in railway axles, which he attributes to the sudden strains and injury produced by concussion and vibration. Those resulting from concussion are chiefly ascribed to a defective state of the permanent way, any sudden obstacle opposing itself to the progress of the train, and the severe shocks arising from the wheels coming in contact with the blocks and sleepers when thrown off the line. The force of vibration, and its certain effect to produce fracture in a body so rigid as a railway axle, is then fully explained; the evil arises from the impossibility of diverting from the axle the continued series of slight blows, or vibrations, to which it is subject, or of causing a free circulation of them through its entire length, since the naves of the wheels being fixed tightly on to the axles, form a point on either side for the vibrations to cease, and the particles of iron composing the axle at this point become dislocated by the continued and unequal strain, and ultimately break; the same action is described as taking place in the journal of the axle, and hence the fact that an axle seldom breaks excepting at the journal, or at the back of the nave of the wheel. The twisting strain to which railway axles are subject, is next considered, and a calculation entered into, to prove that upon a circle of only a few feet in diameter, and assuming a first-class carriage on four wheels to weigh 6 tons, the strain resulting from this cause is so slight, as to be unworthy of consideration in the inquiry. The paper next proceeds to point out, how and why the hollow axle is better able to resist the strains before referred to, than the solid ones now in use.

First, by the process of manufacture, by which the crystalization of the iron is avoided, and it is left in a better state for sustaining sudden strains and continued action. Secondly, by the position of the metal composing the axle, since the comparative strengths of axles are as the cubes of their diameters, and their comparative weights only as their squares,—consequently, with less weight, there must be increased strength: and thirdly, that the vibration has a free circulation through the length of the axle, no part being subject to an unequal shock from the vibration, and the axle would, therefore, receive much less injury from this cause. In conclusion, it is submitted that a railway axle should possess the greatest possible degree of rigidity between the wheels, to prevent it from bending, or breaking from concussion, combined with the greatest amount of elasticity and freedom in the particles of iron within the axle itself, to prevent the injurious effects of vibration.

The details of a numerous set of experiments are then given, to prove the superiority of the hollow axle in all these respects; the average of the whole of which is thus stated.

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the middle.

Hollow Axles.						Solid Axle.			
Weight.				Deflect'n.	Perman't Set.	Weight.		Deflect'n.	Perman't Set.
Tons.	Cwt.	Qrs.	Lbs.	Inch.	Inch.	Tons.	Cwt.	Inch.	Inch.
7	14	. .	6	$\frac{1}{16}$	. .	7	14	$\frac{5}{16}$	$\frac{1}{16}$
9	2	. .	. .	$\frac{3}{16}$	. .	8	1	$\frac{3}{8}$	$\frac{5}{32}$
9	16	. .	. .	$\frac{3}{8}$	$\frac{1}{8}$				

As regards its capability to resist a falling weight:—

5 cwt. 3 qrs. 6 lbs. falling from a height of 16 feet on to the centre of the axle.

Hollow Axle.			Solid Axle.		
1st blow, deflection,		1⅓	1st blow, deflection,		1¾
2nd "	"	2¼	2nd "	"	3¼
3rd "	"	3¼	3rd "	"	4¼

As regards the elasticity and fibrous quality of the journals:—

Hollow Axle.		Solid Axle.	
Number of blows to destroy journal (average),	28	Number of blows to destroy journal (average),	10

Proportions of axles:—

	Hollow Axles.	Solid Axles.
Diameter,	4 inches.	3½ inches.
Weight,	1 cwt. 2 qrs. 20 lbs.	1 cwt. 3 qrs. 24 lbs.

The paper is illustrated by specimens of the broken axles, both hollow and solid, and by diagrams of the mode of manufacturing the two kinds of axles.

Mr. Geach presented a series of specimens of ends broken off solid axles, made by the Patent Shaft and Axle Company, Wednesbury; they had borne severally 886, 148, 293, and 278 blows of a sledge-hammer, weighing 38 lbs., before they separated from the body:—above twenty more ends had been broken off, the weakest requiring 138 blows. The diameter of these journals was 2½ inches.

An axle was exhibited which had been bent nearly double under an hydraulic press, with a pressure of 64 tons: the journals (2½ inches diameter) were also bent in opposite directions, by repeated blows of a sledge-hammer, without any signs of fracture being perceptible.

The firm, which Mr. Geach represented, had made upwards of twenty-five thousand axles, and had tried a very large number by breaking them; they almost uniformly found them of good quality,

which might be attributed to the mode of manufacture. Around a centre bar of iron were placed eight bars, rolled to a proper form, to complete a circle, the joints radiating from the centre; they were then welded together by rolling, and finished under the hammer; the fibre of the iron, it was contended, was thus worked, and remained in its most favorable position.

He was not opposed to the principle of hollow axles, but he wished to prevent any unnecessary prejudice against solid ones, by inferences from any one set of experiments; he would, therefore, suggest that another series of experiments should be made between the relative strength of the two kinds of axles, for which he would contribute the necessary number of solid ones.

Mr. York described the manner in which the solid axles had been selected for the purpose of experiment. Having obtained General Pasley's consent to be present on the occasion, he ordered axles from the Patent Axle Company, and another eminent maker, and selected also several other axles supplied by the Patent Axle Company to the London and Birmingham Railway; these axles were new, never having been under any carriage; he contended that the result of the experiments afforded a fair specimen of the axles generally in use, and were such as the public were in the habit of riding upon. The axles which had since been made by the Axle Company, and were then exhibited to the meeting, showed a quality of iron that could not be surpassed: if this was the usual quality made use of by that company, it still more forcibly proved his position as to the uncertainty of manufacturing solid axles, for while one specimen took a great number of blows to break it, the majority of them were fractured by a slight force; it was this uncertainty which he proposed to avoid, and he contended that it was inseparable from the method of making axles described by Mr. Geach; for, in passing the faggot through the rolls to weld the bars together, it frequently happened that they were only united to a depth of one-half, or three-quarters, of an inch; hence, it was, to a certain extent, hollow, and partially avoided the injurious effect of hammering; if, on the contrary, they were perfectly welded, the iron became crystalized, as in any other solid axle: this fact was proved by the specimens before the meeting, those that were solid having been broken by a very little force, and the unsound ones requiring a great number of blows to produce fracture.

In the experiments, the hollow axles had broken under a different number of blows, but this was owing to their having been made of larger diameter in the journals, than the solid ones, (but with only an equal quantity of metal in them,) and afterwards turned down to the same diameter, which left them of unequal thickness, and too thin for a fair test; still, however, with less metal than in the solid ones, they were stronger; this might be accounted for by the mode of manufacture, as by retaining the axle hollow, the crystalization of the iron was avoided.

The present mode of making the hollow axles, he described to be by taking two trough-shaped semi-circular pieces of iron, bringing their edges together, and welding them under a hammer between

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swages. He, however, dissented from the process of hammering, and intended to finish his hollow axles by compression only. This, he contended, would avoid the injury done to the iron by the present mode of manufacture, and that with the same quantity of iron, the strength of axles being as the cubes of their diameters, and their weights only as the squares, a hollow axle must possess considerable advantage over a solid one.

Hollow axles had long been considered desirable, but the expense of making them had hitherto prevented their use; he had reduced their cost, by his process, to the same rate as the solid ones, and felt confident that in bringing them under the consideration of the profession, through the Institution, they would be faily treated, and ultimately adopted.

General Pasley confirmed the correctness of the results recorded by Mr. York, and the satisfactory nature of the experiments which had impressed him with a favorable opinion towards hollow axles. It was of importance to avoid deflection, as it was almost as fatal as fracture in causing accidents. After the late accident on the North Midland Railway, he observed a solid axle bent into the form of the letter C, and the upper portions of the periphery of the wheels nearly touching each other. The hollow axles would certainly resist deflection better than solid ones of corresponding weight.

In answer to a question, Mr. York said that the iron was chiefly injured by the amount of hammering which it received in forging.

Mr. Taylor remarked, that the question of the amount of injury received by iron in working, was discussed at the meeting of the British Association in 1842, and the effects of vibration and electricity had also been treated of by foreign engineers. It appeared to be generally admitted, that the great source of mischief was the cold swageing, which the iron received, in order to give the work a good appearance. In order to test this, Mr. Nasmyth subjected two pieces of cable bolt iron to 160 blows between swages, and afterwards annealed one of the pieces for a few hours. The unannealed piece broke with five or six blows of a hammer, showing a crystalized fracture; while the annealed piece was bent double under a great number of blows, and exhibited a fine fibrous texture. The fact of the fibre being restored by annealing was well understood and practiced by smiths, particularly in chain-making.

Mr. York could not entirely subscribe to the great benefit of annealing, as he had found that after annealing one end of a hollow axle for forty-eight hours, it was broken off by 32 blows, while the other (unannealed) end of the same axle resisted as far as 78 blows.

In answer to a question from Alderman Thompson, Mr. York said, that he had found as much mischief arise from over-heating iron, as from over-hammering it; but the difference of the appearance of the fracture, indicated immediately when iron had been burned.

Mr. Taylor said that in Mr. Nasmyth's experiments, the over-heated iron was almost as fragile as glass.

Mr. Gravatt believed that vibration, whether caused by the smith in working the iron, or by the use to which the bar was appropriated,

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was the reason of its fracture, and it was certain that a constant change was going on in all manufactured iron. At the Thames Tunnel, the "fleeting bars," used as levers for turning the large screws for forcing forward the shield, never lasted longer than three or four weeks, although they were very strong, and were made from the best materials by careful smiths. They were only used occasionally, and then without any concussion, having only the power of eight men exerted upon them: yet they broke constantly, and the fracture exhibited a bright crystalized appearance. It was found at last, that in order to give them duration, they should be left rough, and not hammered much in working.

Mr. Newton observed, that full ten years since, Dr. Church had used hollow axles for his experimental steam coach on common roads, being convinced of their superiority.

Mr. Fox was an advocate for the hollow axles, but he did not consider the present experiments quite conclusive, as there were differences in the relative dimensions of the axles experimented upon; he would suggest another series of trials, upon a larger number of axles, as the subject was one of great importance, not only to manufacturers, but to the public, whose safety in travelling depended upon the goodness of the axles under the carriages. He had used upwards of 5000 axles made by the Patent Axle Company, and had made many experiments by breaking them; the average result was equal to that quoted by Mr. York. He agreed in the danger arising from overheating iron, as also from over-hammering it, and for some time past he had caused all the axles to be made 6 inches longer than was necessary, in order to cut 3 inches off each end, to try the quality and the appearance of the fracture of the iron.

The President remarked, that there could not exist a doubt as to the greater strength of a hollow axle, as compared with a solid one: both containing the same weight of material; the principal question to be considered was that of vibration, and its effect upon the cohesive strength of the metal, whether the action upon the particles was more irregular in the solid body, and more distributed in the hollow one: he recommended this investigation to some of the mathematicians who were present; the result of their inquiries might materially aid in the development of truth from the practical experiments.—[*Trans. Inst. Civil Eng.*]

Lond. Journ. Arts & Scien.

Flying Machines. By John Bishop.

We are not destitute of data for estimating the force which is called into action in order to sustain, and keep in motion in the air, bodies more or less heavy; sufficient has, at least, been done to enable us to form some conjecture respecting the probability of the success of Mr. Henson's machine. An elaborate memoir, on this subject, by M. Chabrier, has been published by the Institute of France, in which will be found a profound mathematical inquiry into the conditions necessary for the movement of machines in the air. In Dr. Todd's Cyclo-

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pædia of Anatomy and Physiology, part 23, article *Motion*, I have contributed a number of illustrations, by ascertaining the weight of various insects, bats, and birds, and the amount of surface in each respectively. I have also computed the number of strokes made in a second by the wings of the rook and the pigeon during flight. It appears that the average weight of the pigeon is 4347.344 grains; that of the rook 4170.25 grains; and that of the canary 229 grains; whilst the areas of their wings are respectively 0.6198, 1.11, and 0.054 of a square foot. Hence, we see that the areas of the wings of birds do not vary as their weight; and that the rook has nearly half a pound weight to the square foot, and the pigeon one pound; the former making two, the latter three, effective strokes of the wings in a second. The weight of the former is, therefore, greater, that of the latter less, in proportion to the surface presented to the wind, than in Mr. Henson's machine.

It must, however, be borne in mind, that in this machine the surface presented to the wind has no motion like the wings of birds, neither does the machine possess the power of ascending vertically. In birds, on the contrary, according to Borelli,* the power of the muscles which move the wings, compared with their weight, is more than 10,000 to 1; whilst their mass, compared with the muscles moving the legs, is as 3 to 1. We agree with M. Chabrier, that the amount of force requisite for ærial progression is so enormous, owing to the rarity of the atmosphere, that it would be impossible for a man to sustain himself in the air by his muscular strength alone, in any manner, in which he is capable of applying it. For example, it is calculated that a man can raise 13.25 lbs. avoirdupois, to a height of 3.25 feet in a second, and that he can continue this exertion for eight hours in a day. In that space of time he will, therefore, exert a force capable of raising 381,600 lbs. to a height of 3.25 feet, or 45,700 lbs. to a height of 26 feet, which, according to M. Chabrier, is the height to which the swallow would raise itself in a second of time, by the force which it is obliged to exert in order to sustain itself in the air. Now, if we suppose the conditions, necessary for flight in man, to be the same as in birds, and that a man whose weight is 150 lbs., could concentrate the muscular power of a day's labor into as short a period as the accomplishment of the object required, the time, t, during which he would be enabled to support himself in the air would be,

$$150\,t = 47{,}700;$$

hence, $t = \frac{47700}{150} = 318''$, or about five minutes.

The surface of the wings in the rook and the pigeon when expanded, will not support them stationary in the air, unless they move with rapidity; for when the wings of the rook are expanded motionless in the air, the bird descends by its own gravity with considerable velocity; and as it has a greater surface, compared to its weight, than Mr. Henson's machine, it follows that the latter would be precipitated

* De Motu Animalium.

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to the earth with still greater velocity, should the propelling apparatus get out of order in its transit through the air.

It appears by M. Chabrier's analysis, that the quantity of force expended to keep a body, whose weight is W, stationary in the air, (all other conditions being supposed the same,) is as $\sqrt{W^3}$ directly, and $\sqrt{\text{density of the air}}$, inversely. I have, however, elsewhere shown that the quantity of force employed for this purpose, by some birds, is rather less than that here stated.

Lond. Mech. Mag.

Description of Lieutenant D. Rankine's Spring Contractor. By Wm. John Macquorn Rankine, Assoc. Inst. C. E.

This paper describes a contrivance for suiting the action of the springs of railway carriages to variable loads, so as to give the proper ease of motion to a carriage when heavily laden, and at the same time to be sufficiently flexible for light loads. Its effect is to make the strength and stiffness of the spring increase in proportion to the load placed upon it. Each extremity of the spring, instead of supporting a shackle, or roller, as in the usual construction, carries a small convex plate of cast-iron. The form and position of this plate are so adjusted, that when the carriage is unloaded, it bears on the extreme end of the spring, thus allowing it to exert the greatest amount of flexibility; but as the plate is convex, the more the load increases, and the further the ends of the spring descend, the nearer does the point of bearing of the plate upon the spring, approach to the centre, or fulcrum, so that the convex plate, or contractor, tends to diminish the virtual length of the spring in proportion to the load, the result of which is to increase the strength of the spring in the inverse ratio of its virtual length, and its stiffness in the inverse ratio of the cube of the same quantity.

The author then gives in a tabular form, the details and the results of some experiments made on springs of this description, which are similar to those now in use on the Edinburgh and Dalkeith Railway. The springs were 4 feet long, each consisting of ten plates, each ¼ inch thick, and 2¾ inches broad. The contractors were cast with a radius of 12½ inches, and so constructed as not to act until the load on each spring exceeded 10 cwt., and with a load of 30 cwt., they should have contracted the distance between the bearing points to 3 feet 4 inches, instead of four feet; by this means the strength of the spring was increased in the ratio of 6 to 5, and its stiffness in the ratio of 216 to 125.*

The advantages stated to be derived from the use of these springs on the Edinburgh and Dalkeith Railway, and other lines, are—That

* Since this communication was made, contractors of great length, and increased radius of curvature, have been applied, so as to produce a contraction of 6 inches at each end of the spring when fully loaded, which increases the strength in the ratio of 4 : 3, and the stiffness in that of 64 : 27. The details of the construction of these contractors, with a drawing of them, as applied to the springs of the carriages on the Edinburgh and Dalkeith Railway, are given in the addendum to the original paper.

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they afford the same ease of motion to a single passenger, as to forty or fifty in one carriage; they save wear, both of carriages and railway track; they produce the strength and stiffness requisite for the maximum load with less weight of metal; they are not more expensive than rollers; and they are not offensive in appearance, indeed, they would not be observed unless they were pointed out.

Ibid.

On an application of the Electrotype Process, in conducting Organic Analysis. By ROBERT MALLET, Ph. D.

An application of the electrotype process has been made by me, which appears of some value to those engaged in the pursuit of organic analysis; I therefore hope a brief notice of it may not be out of place in the Philosophical Magazine. When very high temperatures are required to effect, or complete, difficult combustions with oxide of copper, or chromate of lead, as in the determination of carbon in certain varieties of cast-iron (which indeed suggested the application to me,) the glass tube is liable to soften and get distorted, though of Bohemia glass, and it has been usual to cover it by lapping a spiral strip of thin copper round the tube. This, however, is never in close contact, even when cold, and the tube is liable to be broken either in the lapping, or during the combustion.

The method I have now to mention as a substitute for this, consists in brushing over the outside of the combustion tube with a very thin coat of Canada balsam and turpentine, dusting it over with fine powder of plumbago which adheres thereto, connecting one end of the combustion tube with a copper wire, and plunging the whole into a cell of sulphate of copper, in the common electrotype arrangement. In a few hours the whole exterior of the tube is found covered with a perfect, close, and coherent jacket, or tube of copper, and may now be at once put into use.

The copper covering adheres so close to the glass tube, and is so completely itself an *air-tight* combustion tube of copper, that should the glass tube crack in the combustion, it is of little importance.

The film of Canada balsam between is so indefinitely thin, that its decomposition has no injurious effect. A combustion tube of 18 inches long is only increased in weight about $\frac{1}{10}$th of a grain by this coating, when dry (without the plumbago of course.) For the latter, Dutch gold-leaf may be substituted with advantage.

The glass combustion tube is best filled with the oxide of copper, &c., and subject of analysis, before the precipitation of the copper upon it, and the tube is best drawn out to a neck at the end next the kali apparatus, as well as at the remote one, the former being done immediately after the filling; the latter neck is opened on commencing the combustion, and the union with the train of absorbent vessels is made by cork in the usual way, but in inverse order, that is, the first cork is not inserted *into* the combustion tube, but placed *upon* the drawn-out neck, thus—

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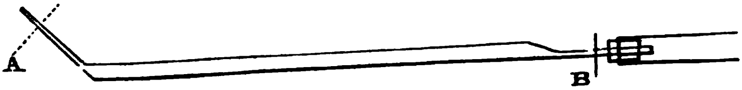

The whole tube from A to B, being covered with copper, the passage for the gases is insured by a sharp blow or two on a table of the combustion tube as usual.

In the methods proposed by Professor Bunsen, of Marburg, some time ago, chiefly for the determination of nitrogen by combustion in a hermetically sealed tube, he imbedded the combustion tube in a mould of plaster of Paris, to prevent the elastic gases evolved from bursting the tube. The process was difficult and uncertain, but the application of the method above described, gives as much facility to the performance of organic analysis by this method, as by any other.

This mode of precipitating copper upon glass, is also susceptible of many other useful applications, in the arrangement of chemical apparatus, when heat, or pressure, is concerned.

Lond. Edin. & Dub. Philo. Mag.

On a method of Etching on Hardened Steel Plates, and other Polished Metallic Surfaces, by means of Electricity. **By J. H. Pring, M. D.**

I herewith transmit to you a rough specimen of what I conceive to be a novel employment of the power of electricity, and shall be gratified, should the process by which it was effected, prove susceptible of any useful application to the arts.

The method which I employed in the production of the characters on the accompanying plate,* was the following:—Having six batteries of the kind invented by Mr. Smee, the platinized silver plate of each being about three inches square, I attached the steel plate to be etched upon, to the zinc extremity of the batteries, a coil of covered wire, of considerable length, being previously interposed between the steel plate and the zinc: then taking the wire connected with the platinized silver in my hand, I used it as an etching-tool on the steel plate—an electrical spark of great brilliancy, accompanied by a slight indentation on the steel, was the result of each contact of the wire with the plate.

The wire by which the etching was made was of platina; the part at which it was held, was carried through a glass tube for the purposes of affording a more convenient handle, and of protecting the hand from shocks to which it might otherwise have been exposed.

By using the wire connected with the zinc of the batteries as the etching-tool, and attaching the steel plate to the platinized silver, a very different effect is produced. With the apparatus thus arranged,

* This was a steel plate, on which the words "Etched by means of Electricity. Bath. 30th June, 1843. J. H. P." together with some ornamental devices, had been produced by the above method. It gave only a faint, just legible impression, by the copper-plate press.—Editor.

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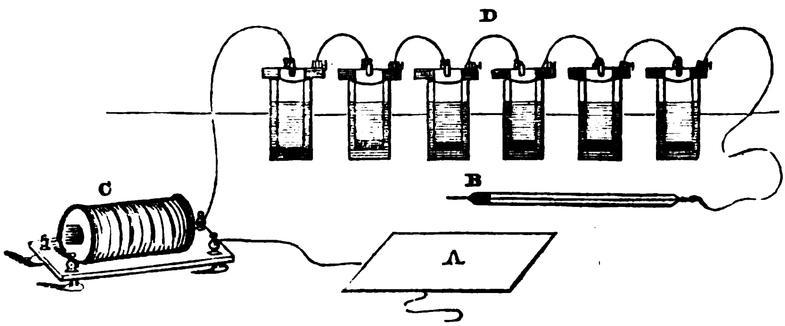
is accompanied by a deposition of a minute portion of the substance of the wire on the steel; by using different wires, therefore, as of gold, silver, platina, &c., a variety of ornamental designs may probably be formed on polished steel surfaces.

The effect of the electrical agency here described, is not, however, confined to steel; a somewhat similar one may be obtained by substituting plates of other metals. By augmenting the quantity and intensity of the electrical current, it seems probable that the effect on the steel, or other metals, would be proportionally increased; and it may be anticipated that, by other modifications of the process, its applications may be advantageously extended.

The accompanying sketch, in which the apparatus is represented lying ready for use, may, perhaps, serve to illustrate the foregoing description.



A, the steel, or other metallic, plate to be etched upon.
B, the etching point of platina wire projecting from the glass handle.
C, the coil of covered wire.
D, the batteries.

Ibid.

On some Experiments made by a Commission of the Royal Institute of the Pays Bas, with a view of verifying the property ascribed to Oil, of calming the waves of the Sea.

The Annales de Chimie et de Physique, for the month of March, 1842, contain a Memoir, by M. A. Van Beek, on the property possessed by oils of calming waves, and rendering the surface of the water perfectly transparent. After citing many testimonies to prove the existence of this property, and its efficacy, the author goes on to express the opinion that we may find, by the use of oil during tempests, a means of protecting piers, and other marine constructions, against the violence of the waves, by pouring it on the water not far from the sides.

So bold and singular a supposition could not fail to attract the attention of men of science; accordingly, the Academy of Sciences of Paris appointed a commission to examine the subject. But, on this

occasion, it will be neither useless, nor uninteresting, to our readers, to know that the same question has already been agitated in Holland.

M. Van Beek, who is a member of the Royal Institute of the Pays Bas, made a proposal last year at the sitting of the class of sciences, having for its object to prevail on the government to institute experiments with the view of proving that oil had the power of preserving piers against the violence of the sea.

This proposition was not generally approved of. Three members were chosen to examine further into its importance; but these three persons in their turn being by no means unanimous in the considerations and advice which they offered, it was thought that the best way of getting rid of the embarrassment, was to adjourn the consideration of the proposal, and endeavor, before resuming it, to obtain some positive light on the question itself. In consequence, a commission of five members was appointed, with instructions to make direct experiments on the power oil exercises on the waves near the coast: and it is the report of this commission which we are now about to communicate.

The commission nominated from among the members of the first class of the Royal Institute of the Pays Bas, and directed to make experiments on the power attributed to oil, and other fat substances, of diminishing the violence of waves, report what was done and observed by them on this subject.

The commission having chosen the village of Zandvoort, situate on the shore of the North Sea, as the place for making their experiments, agreed to meet there on the first stormy day.

They were obliged, however, to change their intention, and to fix on a certain day, on account of the period of the season (the month of June,) during which tempests are rare; and the blasts of wind of any degree of strength being also of short duration, it would have been impossible for them to have met at the village mentioned in proper time. They came more readily to a decision by considering that, if oil really exercises on the water, in a state of great agitation, the power supposed, it must be still more easy to recognize this property on a sea put in motion by a wind of moderate force. Meanwhile, two of the commissioners, happening to be in the country on a day when the wind was blowing violently, made a trial by pouring a small quantity of oil on the water of a rivulet, and observed an evident change in the appearance and movement of the water.

Another member of the commission made, on the same day, a similar trial on the Spaarne, (a small river near Hærlem,) and obtained the same result.

Encouraged by all these observations, the 28th of June was fixed on for the purpose of proceeding to ulterior experiments.

The commissioners assembled at Zandvoort on the day mentioned, at nine o'clock in the morning. Some of them proceeded a short distance from the shore, in order to pour the oil upon the water, and observe the results; the others remaining on land, and not knowing either at what moment, or how many times, the oil was poured out,

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were to keep their eyes fixed on the waves, which rolled from the boat towards the shore; by these means, their opinion, exempt from all influence, might be considered as so much the more impartial.

The wind was south-west, and of moderate force; the quantity of oil poured out at four different times, namely, at 43, 45, 50, and 54 minutes past nine o'clock, amounted to 15 litres (upwards of 3 imperial gallons); the tide was flowing, and would not reach its full height till 21 minutes past eleven o'clock.

The commissioners who remained on the shore, not having remarked any effect which could be ascribed to the effusion of the oil, and the same thing being the case with those engaged in pouring it, we might already consider the question, if oil poured at a little distance from our piers could protect them from the fury of the waves, as answered in the negative. Nevertheless, the commissioners thought it incumbent upon them to make a second trial at a somewhat greater distance from the shore. Two of them were rowed beyond the rocks, and then cast anchor.

The distance was calculated by the boatmen at 300 yards; the sounding line indicated a depth of about three yards; and the waves were rolling considerably. More than the half of 15 litres of oil was poured out in the space of five minutes (from 15 to 10 minutes before 12 o'clock,) and the commissioners did not observe the slightest effect in relation to the object of their mission. They saw the oil swimming on the surface of the water, partly united in spots of an irregular form, partly extended, and forming a pellicle, and partly mingling with the foam of the waves, and sharing in their oscillatory movements.

When returning to the shore, at the moment of passing the rocks, the commissioners caused the rest of the oil to be poured on the water, and they can testify that it had no effect in diminishing the motion of the waves, for they were many times abundantly sprinkled with the spray. It is unnecessary to add, that those who remained on land, had remarked nothing at all which could be attributed to the effusion of the oil.

After all that has been said and written on this subject, the commissioners are astonished at the negative result of their experiments, and, limiting themselves to the account of them, they add no observations. They believe themselves, however, authorized to assert, as their personal opinion, that the idea of protecting our piers by means of oil, is not a happy one.*

Edin. New Phil. Journ.

Tides at Otaheite.

That it is invariably high water at noon, at the island of Otaheite, has been a received fact ever since the days of Cook; but it now appears, from a tide journal kept at the harbor of Papeete, by Mr. Richardson, R. N., and communicated to the Royal Society by Capt. Sir Edward Belchor, that this is not correct—though, certainly, the

* From Annales de Chimie et Physique. T. vii. p. 371.—The experiments appear to have been conducted on too small a scale to afford satisfactory results.—Editor.

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cause of the tides at this island do present some anomalies very difficult to account for. "By a reference," says Sir Edward, "to the tide registry annexed, it will be found that there are two distinct periods of high water, during each interval of twenty-four hours; and that during the seven days preceding, and seven days following, the full and change, they are confined between the limits of 10 A. M., and 2h. 30m. P. M., the whole range of interval, by day, as well as by night, being about 4h. 27m. Commencing with the seventh day preceding the full moon, viz., the 9th of April, it will be perceived that high water occurs at 10 A. M., this being the greatest A. M. interval from noon; and that on the 16th, at the full moon, it occurs nearly at noon. Passing on to the 23rd, it reaches the greatest P. M. limit at 2h. 30m., and on the second of May it again reaches the noon period. Between the 23rd and 24th, however, a sudden anomaly presents itself; throughout the day of the 23, the variation of the level does not exceed 2½ inches, and the general motion is observed to be 'irregular.' The time of high water is also the extreme P. M. limit. On the 24th we discover that it has suddenly resumed *the most distant* A. M. *period*. viz., 10 A. M., but proceeds regularly to the noon period at the change. Although the differences of level do not, at full and change, exceed 1 foot 4½ inches, still, I presume, that we have sufficient data to establish the fact, that it is *not invariably high water at noon* (as asserted by Kotzebue, Beechey, and others:) and, further, that we have corresponding *nightly periods* of high water. It is evident that the time of high water at full and change may be assumed as that of noon, because we have sufficiently decided changes of level to fix the approximate period of high water. It does not appear by these registers, that any higher levels result from the rollers sent in by the strong sea breezes, (as asserted by several writers,) but rather the contrary, the highest levels being indicated during the night, when the land breezes prevailed."

Lond. Mech. Mag.

GLEANINGS FROM FOREIGN JOURNALS.—No. 1.

New mode of measuring the depth of the Sea.—M. Aimé describes an apparatus for sounding, in which a weight attached to the line may, on reaching the bottom be detached, so that the line is drawn up with very slight resistance. He has affixed to this apparatus a vessel for collecting water at different depths, and made, at Algiers, a series of experiments at various distances from the surface, from about 350 to 2200 yards, from which he infers that the amount of gas absorbed by the water, at different depths, is nearly the same, and that the saline constituents are likewise uniform in quantity.

Ann. de Chim. et de Phys.

On Galvanic Induction.—M. Abria, Professor in the Faculty of Sciences, of Bordeaux, has repeated and varied the experiments of

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Resistance of Earth to the motion of Electricity.—Prof. Jacobi concludes, from his experiments, (Bulletin of the Petersburg Academy, vol. i.) that the resistance of earth, the surface of the ground, to the motion of galvanic electricity, may be considered as nothing, and hence that it may be used to form part of a circuit in telegraphing.

Poggendorf's Ann. March, 1843.

Another new Metal.—Mosander has discovered a new metal associated with cerium, lanthanun, and didymium, in Gadolinite.

Chem. Gaz. Aug. 1843.

Elasticity, &c. of Alloys.—The experiments of M. G. Wertheim show that, 1. In alloys of metals the less the distance of the molecules, the greater the elasticity of the alloy. 2. The coefficient of elasticity of alloys generally, may be calculated from the coefficients of the components. Certain alloys of zinc and copper are exceptions to this rule. 3. The tenacity, limit of elasticity, and tensile power of alloys, cannot be determined from similar particulars in regard to their constituents. 4. Alloys resemble pure metals, in reference to their transverse and longitudinal vibrations, and to tensile power.

Compte Rendu of Acad. Sc. of Paris, May, 1843.

Action of Water on Bodies.—When water dissolves, cold is produced, this is shown by Peltier, by the action on the galvanometer through a thermo-electric current; when water combines, chemically with a body, heat is produced. When water is exposed to electrolization, hydrogen is condensed about the negative electrode, and oxygen near the positive, and if the ends of the wires of a galvanometer be plunged into any part of the fluid, except the middle, a current will be developed from the unequal distribution of the gases.

Peltier in Compte Rendu, &c.

Heat from Comets.—M. Ad. Mathiessen found sensible heat from the zodiacal light, by the aid of Melloni's thermo-electric arrangements. He could detect none in the light from the tail of the great comet of 1843. Ibid.

Speaking Machine.—A machine capable of emitting sounds resembling the human voice, has been exhibited lately at Berlin. The inventor is from Vienna, and named Taber. The sounds of the different letters may be produced separately, or in combination. The voice is also susceptible of modulation.

Poggendorf's Ann. Feb. 1843.

Thermo-electric from Hydro-electric currents.—Poggendorf gives a simple way of proving that a galvanic current passing through the junctions of dissimilar metals, produces a thermo-electric current in the same direction, and with the same electro motive force as its own. One pole of a thermo-electric battery is connected with one pole of a

* Amer. Philos. Soc. Trans. Vol. viii.

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galvanic battery, and with a galvanometer; a wire from the other pole of the thermo-battery is made to touch alternately, for an instant, the other pole of the galvanic battery and the galvanometer, so that the force which acts upon the galvanometer needle, is alternately that of the hydro-electric current, and of the thermo-electric current produced by it. The needle of the galvanometer continues its motion, and reaches the same point that the hydro-electric current would have carried it to, had it acted the whole time. Ibid.

Professor Knorr, of Kasan, in his experiments on the cause of the images produced on metallic plates by coins and similar articles, found the following significant result. When the temperature of the air was between −8 and −19° Fahrenheit, an engraved copper plate was placed upon a polished plate, and left there from six to twenty hours. The vapor of iodine brought out no picture on the polished surface, while breathing on similar plates which had been in contact at a temperature of 66° Fahrenheit, sufficed to show an image.

Poggendorf's Ann. April, 1843.

Amalgam of Sodium in a Galvanic Pair.—F. C. Henrici substituted an amalgam of sodium for zinc in a galvanic pair on a Daniell's constant battery. The amalgam readily adhered to a brass wire so that the exchange for a zinc cylinder was easy. When a very small mixture of sulphuric acid and water was used as the exciting liquid about the zinc, or amalgam, cylinder, the following results were obtained. In ten minutes with the zinc cylinder, 7 parts of gas were collected in a voltameter, with the amalgam cylinder 92. In twenty-three minutes, 265 with the amalgam cylinder; in forty-five minutes, 34 with the zinc. In 208 minutes the decomposition, when the zinc cylinder was used, amounted to 237 parts, or less than the result in twenty-three minutes with the amalgam cylinder. With a saturated solution of common salt, instead of the dilute acid, the results were in five, ten, and fifteen and one-third minutes, when the amalgam cylinder was used, 115, 190, and 265 parts, and in five and ten minutes respectively, with the zinc cylinder, 38 and 62 parts. With a stronger mixture of sulphuric acid and water, the amalgam cylinder gave 3[illegible] parts in one minute, and the zinc 51½ in ten minutes.

Ibid. Feb. 1843.

Jupiter's Moons.—A Japanese Encyclopædia published prior to A. D. 1713, gives, according to Libri, a figure of the disk of the planet Jupiter, accompanied by two small stars, and the text states that they appear to be connected with (as it were dependants on) the planet.

Ibid.

Level of the Caspian.—M. Hommaire Dehel finds, by leveling along the streams emptying into the Sea of Azof, on one side, and into the Caspian, on the other, that the Caspian is 18,301 metres (about 20,000 yards) below the Sea of Azof. He denies that the Caspian is the centre of a depression sui generis, but concludes that it occupies the lower part of a basin which the sea once filled.

Compte Rendu of Acad. Sc. of Paris, 1843.

Images on Resin.—When an electric discharge is passed through

a coin placed upon a cake of resin, the base of which communicates with the ground, the part of the cake impressed separates minium from a powder of sulphur and minium rubbed together, and thrown in dust upon the surface. (Masson.) Ibid.

Images on Glass.—M. Karsten states that if an electric discharge be passed through a coin placed upon a glass plate, an image is impressed on the glass, which may be rendered visible by the vapors of iodine, or mercury, or even by breathing upon it. Ibid.

Corona and Beads during a Solar Eclipse.—The appearance of the *corona*, or glory, which surrounds the moon during the time of total darkness in a solar eclipse, and the *beads* which occur prior to the period of total obscuration, and also in annular eclipses, have been imitated by Professor Baden Powell, in the following manner:—A candle is placed in the focus of a lens, placed in a screen, with an aperture of about three quarters of an inch in diameter; on the opposite side of the screen is placed an opake circular disk, of a diameter equal to, or greater, than the aperture, which may be placed at different distances, so as to produce an eclipse of any magnitude, as the spectator changes his position. When the eclipse is total, the glory is seen, and when there are cusps, the beads are seen.

Lond., Edin. & Dub. Phil. Mag., July, 1842.

Electricity from Steam.—Professor Farraday has successfully traced the electricity from steam to the friction of particles of water against the exit pipes. Wood is the best material for the nozzle, when it is intended to show the production of electricity by the escape of steam. The source of lightning cannot be, in his view, the condensation of vapor. Ibid.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Hasty Generalizations in Science.

To the Committee of Publications:

Gentlemen,—At this time, when scientific investigation is going on with so much activity, a proneness to hasty generalizations appears to prevail in many quarters, calculated to injure, rather than serve, the progress of science. Regretting to see a spirit of this sort in a writer, often appealed to, on the important questions of meteorology agitating at the present time, I send you a brief notice of a recent paper by him, in Poggendorf's Annals, with the hope that you will send the number of your journal to Berlin, that he may see how such things look in *abstract.*

Meteorological Deduction.—Professor Dove, of Berlin, has the following assertion in a recent meteorological paper, read before the Academy of Berlin, and published in Poggendorf's Annals. "The peculiar relation [of distribution of temperature] belonging to continents, is not to be found in America." Then is America not a continent, or else the relations to which the Berlin philosopher refers, are not peculiar to continents. The same philosophical spirit is manifested

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"and as Espy has done, see an upward current as draught-leader (zugführer) at the top of a whirlwind, but a glance merely at the storm-charts of Redfield and Reid, is sufficient to show how unnatural the supposition is." Important questions of meteorology dependant upon a glance at a chart, and American meteorology not continental. The journals quoted in the course of the paper, are Captain Parry's at Melville Island; "Ancasters, between Ontario and Erie;" of five years Observations at St. Johns, Newfoundland; and of Observations at Cambridge, Massachusetts. The sweeping conclusions from such insufficient data suit well with the neglect of numerous published registers of authority, but the extraordinary selection of localities from which to form a judgment, could hardly be expected from any one claiming to be a meteorological authority.

M. Clement's Nautical Inventions.

On the Sillomêtre, Sub-Marine Thermometer, Steam Indicator Derivomêtre, and External and Internal Thermometer.—Communicated by Captain Washington, R. N.

Before proceeding to give a description of these instruments, and particularly of the Sillomêtre of Mons. L. Clément, of Rochefort, some account of which appeared in the May number of the Nautical Magazine, it may be as well to state briefly what has been done in former times, as to finding a substitute for the common log, which it must be confessed, is a sufficiently primitive method of measuring the speed of a ship.

1. It is said that as far back as the time of Augustus, it was proposed by Vitruvius, to pass an axle, or shaft, through the side of a ship, having a wheel at each extremity; from the inner wheel a stone fell at each revolution, and the number of stones determined the rate of the vessel's speed.

2. The Marquis De Poleni, who gained a prize from the French Academy for his invention, about the year 1720, proposed to tow a globe at the end of a long line, connected with a lever, which raised a weight at its other extremity, and pointed out the speed on a graduated arc.

3. M. Pitot proposed a machine composed of two glass tubes, the lower end funnel shaped, and bent towards the ship's head, in which the water rose according to the rate of the vessel's going.

4. M. Saverien proposed a globe about four feet below the surface of the water fixed at the end of a long lever, the upper end to raise weights according to the degree of tension, and thus give the rate.

5. The *Marine Surveyor* of Henry De Saumerez, of Guernsey, on being towed astern of a ship, acquired a rotary motion which was communicated to a machine of clock-work on board, whence the rate was shown on a dial.

6. Russel's *Perpetual Log* was a spiral machine towed astern much on the same principle as that of De Saumarez.

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and pinion fixed to the keel of a ship; its movement was communicated to clock-work within, by means of a metal rod.

9. Gotlieb's *Perpetual Log* is an instrument nearly similar, with the addition of a box to guard the exterior wheel-work.

10. The *Nautical Dromometer*, of Benjamin Martin, is an instrument of the same kind, only to be fixed to the side of a ship.

11. Hopkinson, of Philadelphia, proposed a metal lever, with a circular plate at the lower end, against which the water acted, and was regulated by a spring, an index showing the rate of the ship in degrees on a graduated arc.

12. Bouguer, the companion of De la Condamine, in his voyage to Peru, proposed a globe, of 6 or 7 inches diameter, to be towed astern, the other end of the towing line to be connected with a lever which should raise weights according to the rate of sailing.

13. The *Hydroscope* of Count De Vaux, proposed in 1803, consists of one or more globes of six inches diameter sunk in the water, level with the keel, passing through a vertical copper pipe, as near the centre of gravity of a ship as may be; the globe is connected by a brass chain with the end of a horizontal lever, the other end of which communicates with a brass slide attached to a spiral spring; this spring is intended to measure exactly the force of the resistance the globe meets with in passing through the water, which is rendered into knots on a dial, and thus shows the rate of a ship's sailing, or the rate of current when at anchor.

14. An addition to this instrument, by the Count De Vaux, was to show the amount of distance run, by a comparison between two clocks, or, as he preferred, a *clepsydra,* or sand glass, which ran out once in 60 miles, when it required to be refilled; this machine would give the whole distance run, as well as the rate of sailing.

[Captain Beaufort carried out the former of these two plans, we believe, and had it fitted to his boat, during his well known and admirable survey of the coast of Karamania, in 1812.]

15. Massey's *Patent Log*, on the same principle as the Marine Surveyor of De Saumarez, is too well known to need a description, and as far as our experience goes, shows the distance run correctly.

16. The *Marinodometer* of Captain Arthur Bingham, R. N., which, in 1824, he fitted to the keel of the Tourist steamer, was somewhat similar to the *Navivium* of Gilmore, as far as we can learn.

17. A plan not unlike that of M. Pitot, (No. 3.) was fitted to the Rhadamanthus steamer, Captain George Evans, R. N., in 1830, we believe, but was not found to answer.

18. Mr. Purcell, of Hamburgh, in 1841, proposed a square plate, or vane, to be fixed under water at the lower end of a metal rod, the upper end connected with a spring; the amount of torsion is shown on a dial by an index.

19. Ayre's *Patent Log* consists of a small pear-shaped ball towed astern at the end of a line, the other is carried over a heavy roller

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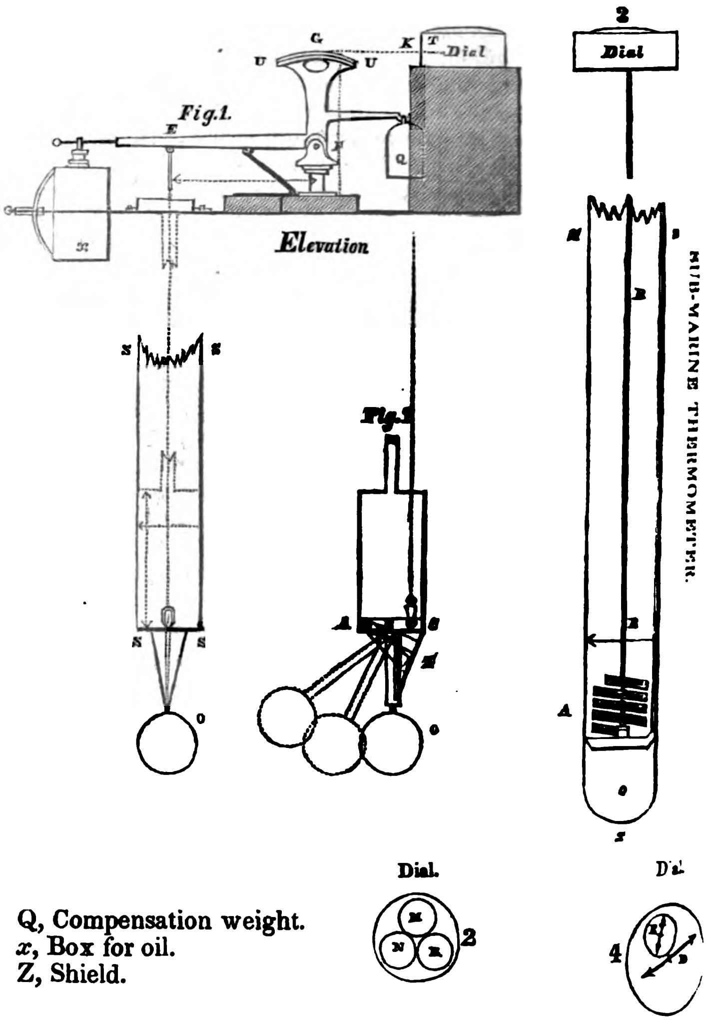
which it turns according to the amount of tension, an index showing the resistance in knots.

Lastly. The *Sillomètre* of M. Clément, which we now propose to describe in detail.

Sillomètre.



Q, Compensation weight.
x, Box for oil.
Z, Shield.

The name, *Sillomètre*, is composed of the two French words *Sillage* (headway,) and *mètre* (measure,) and might be well rendered in English, speed-gauge. This instrument consists of a hollow copper ball, fig. 1, about five inches in diameter, suspended under the ship's bottom, nearly amidships, from the middle of a bent lever, A, C, about five inches long; one end of this lever moves on a joint, A, its ful-

crum, attached to the lower end of a metal rod which passes vertically through a copper tube, carried from the deck through the bottom of the ship near the keel; at the other end of the lever is attached a chain, C, which leads upwards, and acts upon a second horizontal lever, E, F, on deck. This second lever corresponding to the lower one, gives motion, by means of a spring, to an index, which marks on a dial, the speed of the ship expressed in knots, and tenths of a knot.

Such is the whole of the apparatus of the simple Sillomêtre. It will be readily understood, that, as the vessel moves through the water, the fluid acts upon the ball, which being circular, always presents the same section, and causes it to move aft, thereby depressing the fore end of the lever, which, by the chain, communicates with the dial on deck. The scale, by which to graduate the knots on the dial, was found by M. Clément after numerous experiments. This instrument in its simple form, shows the speed of the vessel, not the amount of distance run.

The Compound Sillomêtre consists of the same mechanism, with this addition, that the power which moves the index is applied at the same time to a watch, and accelerates its movements in proportion to the intensity of the moving power, or as the vessel quickens her speed.

A second watch is placed by the side of the first, in order to show how much the former gains upon the latter; and knowing that for every 6 seconds of gain, the vessel will have made a mile, it is easy to know the distance run.

It is evident that this compound instrument is very superior to the simple one, but its accuracy depends upon the regular going of two good watches, a result not very easily obtained at sea.

The *Sub-Marine Thermometer* is a very delicate instrument composed of a ribband formed of two metals of unequal contraction and expansion, as platina and silver, and rolled in the form of a helix, A, fig. 3, round an axis, B, which turns as the temperature of the water varies. This motion by a train of wheels and pinions is immediately communicated to two pointers on a graduated dial on deck, and which may be read off easily to hundredths of a degree.

The whole of this apparatus is enclosed in a metal tube, which passes through the bottom well aft in the run of the ship. The helix, or thermometer, is, therefore, always at a certain depth in the water, say 10 feet below the surface; and it shows instantly every change in its temperature.

As few observations have been regularly made on the temperature of the water of the sea at a certain depth, this machine may lead to some novel results.

The *Steam Indicator* points out the temperature and consequent pressure of the steam in the boilers. It is composed of a ribband, or blade, of two sensitive metals of unequal expansion, turned in a spiral form; one end is fixed to the tube, or pipe, in which it is contained, the other connected with a spindle bearing the pointers which indicate the temperature of the steam on a dial on deck, in degrees and tenths

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of a degree. This instrument is connected, by a small pipe, with the boiler, or steam chest, through which the steam reaches the spiral, which instantly causes any variation in temperature to be shown by the dial on deck: in high pressure engines this may be found useful.

The *Derivometer* is an instrument somewhat on the principle of the Sillomêtre, and intended to measure the drift of a ship; this is done by a vane placed on the keel, connected by a rod with a dial—the vane, of course, takes the opposite position to the drift of the vessel, which is communicated by the turning of the rod to the pointers on the dial on deck.

The *Internal and External Thermometer*, as its name indicates, is a highly sensitive thermometer, so placed against the wall of an observatory, or house, as to show the temperature of the air within and without. The two pointers, which mark this, are on the face of the same dial.

We believe that Her Majesty has ordered such an instrument to be placed in one of the apartments in Buckingham Palace.

We now proceed to the trial of the first named three of these instruments, as fitted on board H. M. S. *Blazer*, in April last.

Report.

Monday, 3rd April, 1843.—H.M. steam vessel *Blazer*, having been fitted with three newly-invented instruments by M. Clément, of Rochefort, namely, a Sillomêtre, to measure the rate of speed,—a Steam Thermometer, to indicate the temperature of steam in the boilers,—and a Sub-Marine Thermometer, to show the temperature of the sea at 10 feet below the surface, was directed to proceed down the river, on trial, having on board M. Clément, the inventor, Mr. Cary, who had constructed the present set of instruments, and Mr. Large, of Woolwich Dockyard, who had superintended the fitting of them in the vessel.

Before starting, made a trial under the superintendence of Mr Lloyd, chief engineer, of Woolwich Dockyard, of the temperature of the steam by the steam thermometer, as compared with the elasticity of the steam, as shown by the steam gauge, at each lb. pressure: making due allowance for the height of the barometer, and using the temperature as given in Dalton's experiments, corresponding to the inches of mercury in the steam gauge. The results obtained were as follows:—

	Steam Ther. Centi.		Inches.
At 5⅞ lbs. pressure, 1st exp.	110.4	Barometer,	29.85
" 2nd do.	110.2	Hei't of steam gauge,	10.25
Mean,	110.3		
Temp. by Dalton's tables,	108.7		40.10
Difference,	1.6		

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At 3 lbs pressure, 1st exp.	107.0	Barometer,	29.85
" 2nd "	107.0	Height of steam gauge,	6.00
Mean,	107.0		
Temp. by Dalton's tables,	105.2	- . - -	35.85
Difference,	1.8		
At 1 lb. pressure, 1st exp.	103.3	Barometer,	29.85
" 2nd "	103.3	Height of steam gauge,	2.00
Mean,	103.3		
Temp. by Dalton's tables,	101.7	- - - -	31,85
Difference,	1.6		
At 4 lbs. pressure, 1st exp.	108.4	Barometer,	29.85
" 2nd "	108.4	Height of steam gauge,	8.00
Mean,	108.4		
Temp. by Dalton's tables,	106.9	- - - -	37.85
Difference,	1.5		
At 2 lbs. pressure, 1st exp.	105.4	Barometer,	29.85
" 2nd "	105.3	Height of steam gauge,	4.00
Mean,	105.3		
Temp. by Dalton's tables,	103.4	- - - -	33.85
Difference,	1.9		
At 0 pres. safety valve open,	101.3	Barometer,	29.85
Temp. due to height of barom.	99.7		
Difference,	1.6		

Tested also the Sub-Marine Thermometer by sinking one of Newman's Standard Thermometers 10 feet below the surface of the water, and keeping it there half an hour, At high water the temperature by M. Clément's Sub-Marine Thermometer was 45°.9; by Newman's Mercurial Thermometer 40°.0. Temperature of air 47° Fahrenheit.

Tried also on shore in the dockyard, by a quadrant, the angles at which the centre of the ball of the Sillomêtre would stand when the index marked different knots on the dial, and found as follows:

The ball left to hang, with the chain loose, being in the position taken in the water when at rest.

The chain tight,	0	deg. on quadrant.	0	knots on dial.
"	10	"	0	"
"	15	"	2.2	"

The chain tight,	20 deg. on quadrant.	4.5	knots on dial.
"	25 "	6.6	"
"	30 "	8.6	"
"	35 "	10.3	"
"	40 "	11.5	"
"	45 "	12.1	"
"	50 "	12.8	"

Passage from Woolwich to the Nore.

Time.	Rate of going.		Steam Thermometer		Sub-marine Thermomet'r.		Dp. wr.	Tm. air.
P. M. h. m.	Sillom.	Log.	Centi °	Fahrn. °	Centi °	Fahr. °	fm	°
3 45	5.8		110.5	230.90	9.40	48.92	5½	59
	6.7							
4 0	6.1				9.20	48.56		
	6.4	6.2	110.0	230.00	9.25	48.65	6	
	6.2							
	6.6		109.6	229.28				
4 15	6.4				9.02	48.04	5¾	
	8.2		110.1	230.18				
	6.0		109.8	229.64				
	5.5							
					8.85		6½	
4 30	6.8		110.1	230.18		47.93		
	5.8							
4 45	7.5		110.1	230.18	8.75	47.75	7½	
	6.0		110.7	231.26	8.60	47.48	8	
	6.2							
5 0	6.2	6.2	109.5	229.10	8.55	47.39	8½	56
	6.6		109.8	229.64				
5 15	5.9		109.0	228.20	8.48	47.25	7¼	
5 30	6.2		108.8	227.84	8.42	47.16		
	6.8	7.0			8.30	46.94		
	6.9							
5 45	5.6		108.5	227.30	8.32	46.98	9	
	6.5							
6 0	6.2		109.5	229.10	8.30	46.94	7	52
6 15	6.5		108.9	228.02	8.25	46.85	6¼	
6 30	6.0	5.8	109.7	229.46	8.20	46.76	7	
	5.8							
6 45	6.8		109.4	228.92	8.22	46.80	5¼	
7 0	6.3		109.5	229.10	8.13	46.64	5¼	51
7 15	6.5		109.7	229.46	8.10	46.58		
	6.4				8.08	46.56		

Remarks, Monday, April 3, 1843.

At 3h. 45m. started from Woolwich, moderate breezes and fine; wind W.S.W. 2; barometer 29.80.

High water; draught of water forward 11 ft. 4 ins., aft 11 ft. 8 ins.

Boilers filled with fresh water.

Sillomêtre put in action just abreast the Dockyard.

Adjusted the chain to the rate shown by the common log.

Altered the helm continually to avoid vessels in streaming down the river; at each spoke of the wheel the Sillomêtre showed a decrease of rate, when put hard over the speed fell from 7 knots to 4.

At 4h. 20m. the Sillomêtre showed a speed of 8.2, which is certainly beyond the power of the vessel.

At 4h. 30m. put over Massey's Log.

At 5h. off Greenhithe. Variations of speed as shown by Sillomêtre, while heaving the common log,

		5.4
		5.6
"	"	5.3
"	"	6.[illegible]
"	"	5.5
"	"	5.[illegible]
	Mean,	5.[illegible]

At 5h. 45m., in 9 fathoms, the Sub-marine Thermometer indicated no difference of depth. At 6h. off Sheerness. In 2¾ hours, Massey's Log showed a distance of 21.6, which exceeds that given by the Sillomêtre or common log.

At 7h. 30m. anchored at the Nore. Tried the temp. of water by Mercurial Thermometer, and found it to agree exactly with M. Clément's Sub-marine Thermometer, namely, 46°.5.

The Sillomêtre throughout this passage was very sensitive, showing immediately the change of rate due to a single spoke of the wheel.

The Steam Thermometer varied regularly with the temperature of the steam as shown by the steam gauge, but generally stood 3° of Fahrenheit, in excess.

The Sub-marine Thermometer showed a gradual decrease of temperature as we approached the sea, which was unexpected, but it agreed exactly with the best mercurial thermometers.

Remarks.—It will be seen from the above table, that the Sillomêtre showed every variation in the speed of the vessel, even the alteration caused by a single spoke of the helm was perceptible, and putting the helm hard over, caused the ship to lose half her way almost immediately; as the dial of the instrument is placed on deck, and the index, or pointer, very conspicuous, the officer of the watch, without any trouble, may observe it at every turn he takes on the quarter deck; and it is obvious that none but the most inattentive person can fail to have a much more correct knowledge of the rate of the vessel's going, than he can from heaving the common log once or twice an hour. The Sillomêtre will also enable an officer easily to ascertain the best trim of a vessel; the difference caused by shaking out a reef, or by making, or shortening, sail; and in a fleet would enable a ship to keep her station by night, or by day, with great steadiness; and lastly, it impresses very strongly, on the observer, the absolute necessity of good steering, and giving very little helm when in chase, or on a trial of sailing, or at any other time when speed is of importance.

The *Steam Thermometer* has also a dial placed on deck, so that the officer of the watch can tell at any moment whether there is a sufficiency of steam, or the contrary, and can thus check the wasteful expenditure of coal; it would point out, too, the possible, but highly improbable, occurrence of no water in the boilers, or an undue increase of the temperature of steam from any other cause. Its chief value, however, would be shown in a high pressure engine, when it would give, immediately, warning of any approach to such a degree of temperature, or pressure, as might be dangerous.

The *Sub-marine Thermometer* remains constantly at a depth of about ten feet below the surface of the water, and owing to its being formed of platina and silver, is extremely sensitive, and thus every change in the temperature of the sea will be shown at once on the dial on deck.

As in the Atlantic Ocean, and in other deep seas, the deep water is said to be warmer than the shallow, it probably would there show, by mere inspection, the approach to shoals, rocks, or land, and serve as an excellent warning. At this season of the year, however, in the shallow waters of the North Sea, we observed no such effect, on the contrary, the temperature of the water gradually decreased from 50° Fahrenheit, at Woolwich, to 44½°, at about twenty miles to the eastward of the North Foreland, and as gradually increased on our return to the same point.

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day. As the Thermometer is highly sensitive, and may be read off with ease to hundredths of a degree, and agrees perfectly with the best mercurial thermometers, it many possibly furnish some novel results of value to the philosopher, as well as to the navigator, since I am not aware of the existence of any continued series of observations on the temperature of the sea, at all seasons of the year.

I would venture to recommend that the instruments, after coming from the hands of the maker, should be put to the severest test by competent persons before being finally placed in a ship.

The instruments fitted on board the *Blazer*, appear to be carefully made and well finished; they are conveniently and securely placed in the ship, nor does there seem to be any fear of their being deranged.

Harwich, April 12th, 1843. Lond. Naut. Mag.

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Electro Chemical Silvering.

A report made by M. Becquerel, in his own name, and in those of M. Dumas, and Hericourt de Thury, to the Academy of Sciences of Paris, session of July 10th, 1843, upon a communication made by M. Mourey, concerning an useful modification of the processes hitherto used in electro-chemical silvering. Heretofore the articles silvered by the electro-chemical process have been, indeed, when first taken from the apparatus, of a perfect mat-white, which, however, they soon lost, and in a few days their surface became of a dirty yellow, which diminished their value. If we endeavored to color them as in gilding, the silvering was injured. The process of M. Mourey is intended to avoid this difficulty. In electro-chemical silvering, as in all the decompositions effected by means of electricity, the article which is covered with silver attracts to itself, at the same time, all the electro positive elements which are in the solution, so that in the case before us, there is a sub-cyanide of silver, a compound upon which light acts to change its color. The object then is to destroy this compound without the use of acids. M. Mourey has succeeded in this by a very simple process. He covers the articles several times with a solution of borax, and then submits them to a temperature so high that the borax begins to melt, then plunges them into water acidulated with sulphuric acid, and suffers them to remain some time. The articles when washed and dried acquire the most beautiful lustre which virgin silver can take. This lustre remains so long as the articles are not exposed to sulphurous vapors.

Galvanic Bronzing.

M. Becquerel again exhibited to the Academy, new specimens of his metallic applications. In communicating, at the last session, the

from ultimate injury, he had remarked that it was possible so to vary the colors of the coatings, as to present effects agreeable to the eye, which might be of use in the arts. Wishing to satisfy himself as to the extent to which this might be carried, M. Becquerel multiplied his experiments, and arrived at remarkable results. He has obtained various and brilliant tints, which he compares to those presented by the wings of tropical beetles. The articles which receive these tints acquire more brilliancy when they are rubbed with leather and jewellers' rouge; that is, the coatings which produce them have a strong adherence—the bronzing rendering the surface more brilliant, determines the reflection of a greater quantity of light, and, consequently, must increase the brilliancy of the color.

The principle upon which the coatings are formed, is, that whatever be the surface of the metal, such will be the deposited coat, so long as it is thin; but as the deposit takes place when the metal is electro-positive, that is when the oxygen tends to oxidize the surface, (if the metal be oxidizable) the coloring effects are only produced with non-oxidizable metals, such as gold, or gilded copper, the surface of which is brightly polished. Thus gold is the metal upon which the rich colors, shown by M. Becquerel to the Academy, were deposited. These effects were produced only by the solution of protoxide of lead in potassa. It requires but one or two pairs of plates, but the operation must be carefully watched, for it lasts sometimes not more than a minute. The colors obtained are light-red, flame-red, deep-red, violet-blue, and finally, a very deep color. The articles must be continually withdrawn from the bath, in order to obtain the tint wished for. If the action be too strong, the hydrated peroxide of lead is formed, which is precipitated in yellow floculi through the solution, without the production of the colors. It is, therefore, necessary to watch the operation every instant, which is so easy, that a number of articles may be operated on at the same time, and always with the same success. M. Becquerel has hitherto confined himself to the effects produced by oxides of lead and iron; in another communication he will give the results obtained with other oxides.—*L'Inst.*

A new and easy method of covering Copper and Brass with Platina.

One part of solid chloride of platina is dissolved in 100 parts of water, and to this solution is added 8 parts of common salt; or, still better, 1 part of platino-chloride of ammonia, and 8 parts of hydrochlorate of ammonia are placed in a flat porcelain vessel, 32 to 40 parts of water poured over it, the whole heated to boiling, and the vessels of copper or brass, perfectly bright, are placed therein. They will be covered in a few seconds with a brilliant and firmly adhering layer of platina.

There is no doubt that this method may be employed with the greatest advantage in pharmaceutical laboratories.

Annals of Chemistry.

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On Tinning and Zincing Copper and Brass by the moist way.

Plates of copper, or brass, placed in a boiling solution of stannate of potassa mixed with turnings of tin, are, in the course of a few minutes, covered with a firmly attached bright layer of tin—a method very useful for tinning pharmaceutical instruments.*

A layer of zinc may also be obtained on the same metals by employing chloride of zinc: pure zinc turnings being present. The same object can be attained by means of zinc, and a solution of hydrochlorate of ammonia.—*Boettger's Beitrage.* Ibid.

On colored Fires.

There are very many receipts for colored fires, differing in some slight degree from each other. The following, I believe, *from experience,* to be the best:—

Red fire.—Sulphur, 1 ounce; sulphuret of antimony, 1 ounce; chlorate of potass, 1 ounce; nitrate of strontian, 5 ounces. The chlorate of potass, being previously well powdered, should be mixed carefully on a paper with the sulphuret of antimony, and afterwards the remaining ingredients should be added, and well mixed with a spatula on paper.

Blue fire.—Nitrate of barytes, 77 parts; sulphur, 13 parts; chlorate of potass, 5 parts; realger, 2 parts; charcoal, 3 parts. Mix them thoroughly.

Purple.—Lamp black, 1 part; realger, 1 part; nitre, 1 part; sulphur, 2 parts; nitrate of strontian, 16 parts; chlorate of potass, 5 parts. Ibid.

Researches on certain circumstances which influence the temperature of the Boiling Point of Liquids. By M. F. Marcet.

Philosophers generally admit that the temperature at which any liquid enters into ebullition, depends, 1st. On the nature of the liquid:

* "The same experiment," remarks Mr. Wittztein, "was performed by Trommsdorff fifty years ago." I will here give his own words (in Götting's Taschenbuch für Scheidekünstler. and Apoteker Jahrgang, 1791, s. 128,) on this subject.

"*Singular Tinning by the moist way.*—Several vessels of pure English tin were boiled in a portion of caustic ley, in order to clean them. The ley was decanted, and remained standing during one night, in a copper kettle, for further use. The following day, when the kettle was employed, the surface of it, so far as it had been covered by the ley, was discovered to be tinned; and the kettle was used for a long time before this tinning was worn out. Although this might not prove a very economical means for tinning vessels, it might, perhaps, be employed with advantage in those vessels, the shape of which does not admit of their being tinned in the common way."

Further, he states, in the same work, in the year 1792, p. 193:—

"Last year I announced to the public the observation, that caustic fixed vegetable alkali dissolves zinc by the moist way, and is precipitated therefrom in a metallic form by copper: I have since repeated the experiment with complete success. Caustic mineral alkali, and volatile mineral alkali, show the same phenomenon, but it does not always succeed so well as with vegetable alkali."—*Buchner's Repert.*

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2nd. On the atmospheric pressure; 3rd. On the nature of the vessels in which ebullition takes place. It is to this last point that M. Marcet has particularly directed his attention; and after an immense number of experiments, he has arrived at the following conclusions:—1st. That the boiling point of water, in glass vessels, varies between 212.54° and 215.6°, according to different circumstances, and particularly according to the quality of the glass employed. In every case the temperature of the steam furnished remained sensibly the same, and is constantly lower (the fraction of a degree) than that furnished by water boiling in a metallic vessel.

2nd. Whatever the nature of the vessel employed, the temperature of the steam furnished is always beneath that of the boiling liquid which furnishes it. When glass vessels are employed, this difference, at a medium, is 1.9° F.; if metallic vessels be employed, it varies from 0.27° F. to 0.36° F. There is only one exception to this rule, which is, when the vessel, whether of glass or of metal, is covered with a thin layer of sulphur, or shellac, or any analogous substance, having no sensible attraction for water. In this case only, the temperature of the vapor is found identical with that of the boiling liquid which furnishes it.

3rd. Contrary to the generally received opinion, a certain temperature being given, it is not in a metallic vessel that the temperature of boiling water is at the lowest possible degree; for it will be found that in a glass vessel covered with a thin layer of sulphur, shellac, or any other similar substance, this temperature is, by some fifths of a degree, lower than in a metallic vessel.

4th. In vessels made of perfectly pure glass, free from any foreign matter, water, and also alcohol, may be heated, without ebullition taking place, to a temperature much higher than has been hitherto usually believed. We may in particular obtain, in this manner, water (not boiling) heated to 221° F.: if this does not happen in every case, it will be found that the surface of the glass is not perfectly smooth, although apparently so, and that it contains foreign matters, which are adherent thereto, and which may be removed by different methods, more particularly by the action of concentrated sulphuric acid.—*Ann. de Chimie.* Ibid.

Test for Copper.

Verguin observed, by chance, that copper may be disengaged, in the metallic state, from any solution containing it, by feebly acidulating the liquid with muriatic acid, and placing it in a capsule formed with platina foil: over this must be arranged a piece of tin plate in such a manner as to touch both the liquid and platina. A deposit of metallic copper on the surface of the platina ensues, which is firmly adherent, and maintains its metallic lustre. The metals should be perfectly clean.—*Ph. C. Bl.* Ibid.

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METEOROLOGICAL OBSERVATIONS FOR JULY, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	71°	92°	29.86	29.86	SW.	Moderate		Clear.	Clear.
	2	77	93	29.80	29.80	SW.	do	.59	Clear.	Rain.
	3	60	73	29.75	29.75	NW.	Brisk		Clear.	Clear.
☾	4	55	78	30.00	30.00	W.S.	do		Clear.	Clear.
	5	66	71	29.90	29.90	W.	do		Cloudy.	Cloudy.
	6	56	78	29.94	29.94	W.E.	do		Clear.	Clear.
	7	60	81	29.95	29 95	W.	do	.16	Par. Cloudy.	Rain.
	8	65	78	29.70	29.70	W.	do		Clear.	Clear.
	9	66	83	29.80	29.80	SW.	do		Clear.	Clear.
	10	67	79	29.80	29.80	SW.	Moderate		Par. Cloudy.	Cloudy.
☉	11	68	63	29.74	29.74	NE.	do	.55	Par. cloudy.	Rain.
	12	65	68	30.00	30.00	NE.	do	.03	Cloudy.	Rain.
	13	64	67	30.16	30.20	NE.	do		Cloudy.	Cloudy.
	14	64	75	30.20	30.15	W.	do		Cloudy.	Cloudy.
	15	68	80	29.95	29.90	W.	do	.75	Cloudy.	Showery.
	16	65	81	29.90	29.90	S.	do		Fog.	Clear.
	17	68	74	29.90	29.90	S.	do		Fog.	Cloudy.
	18	72	87	29.76	29.75	W.	do		Cloudy.	Par. cloudy.
☽	19	70	86	29.75	29.75	W.	do	.03	Clear.	Rain.
	20	62	76	29.75	29.82	NW.W.	Brisk		Cloudy	Clear.
	21	56	77	29.87	29.87	NW.	Moderate		Clear.	Clear.
	22	58	80	29.90	29.90	W.	do		Clear.	Clear.
	23	64	82	29.86	29.86	W.SW	do		Lightly cloudy.	Clear.
	24	68	88	29.80	29.74	SW.	Brisk		Lightly cloudy.	Clear.
	25	66	81	29.90	29.93	NE.	Moderate		Par. cloudy.	Clear.
	26	63	83	30.06	30.06	W.	Brisk		Clear.	Clear.
⊗	27	68	89	29.94	29.94	SW.	Moderate		Clear.	Lightly cloudy
	28	79	90	29.94	29.90	SW.	do		Clear.	Clear.
	29	76	92	29.80	29.76	SW.	Brisk		Hazy.	Par. cloudy.
	30	76	82	29.75	29.67	NE.	Moderate	.03	Cloudy.	Rain.
	31	62	66	29.85	29.90	NE.	do	.90	Rain.	Clear.
		65.97	79.70	29.88	29.88			3.04		

Thermometer. Max. 93, on 2nd. Min. 55, on 4th. } Mean, 72.87

Barometer. Max. 30.20 on 13th & 14th. Min. 29.67 on 30th. } Mean 29.[illegible]

AUGUST, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Baromtr. Sun Rise.	Baromtr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	62°	76°	29.90	29.90	NE.	Moderate		Cloudy.	Par. cloudy.
☾	2	60	79	29.84	29.84	NE.SE.	do		Cloudy.	Par. cloudy.
	3	64	81	29.95	30.00	NE.SE.	do		Cloudy.	Par cloudy.
	4	65	81	30.14	30.25	E.	do		Par. cloudy.	Par. cloudy.
	5	66	70	30.20	30.15	N.	do	3.80	Cloudy.	Rain.
	6	65	76	30.00	30.00	W.	do		Par. cloudy.	Clear.
	7	67	78	30.00	30.00	E.	do	.07	Showery.	Cloudy.
	8	74	77	29.90	29.90	W.	do		Cloudy.	Showery.
☉	9	68	69	29.90	29.96	E.	do	1.65	Rain.	Cloudy.
	10	66	69	29.94	29.86	NE.	do	.15	Par. cloudy.	Rain.
	11	66	76	29 80	29.84	W.	do		Cloudy.	Clear.
	12	64	77	29.86	29.90	W.	do		Par cloudy.	Clear.
	13	66	82	29.90	29.90	SW.	do		Hazy.	Lightly cloudy
	14	66	82	29.85	29.75	W.SW.	do	.35	Fog—clear.	Rain.
	15	68	79	29.70	29.70	W.	do		Cloudy.	Clear
	16	66	80	29.80	29.85	NW.	do		Cloudy.	Clear.
	17	66	81	29 85	29.90	SW.	do		Fog.	Clear.
☽	18	69	83	29.85	29.85	SW.	do		Fog.	Clear.
	19	71	81	29.85	29.85	SE.	do	.15	Cloudy.	Rain.
	20	68	78	29.85	29.80	E.	do		Par. Cloudy.	Clear.
	21	68	78	29.85	29.84	E.	do	.70	Cloudy.	Showery.
	22	70	77	29.84	29.84	W.E.	Calm	·49	Rain.	Par. cloudy.
	23	70	76	29.86	29.86	W.	do	.05	Cloudy.	Rain.
	24	65	78	29.88	29.90	W NE.	do		Cloudy.	Clear.
⊗	25	66	79	29.98	29.98	NE.	do		Cloudy.	Clear.
	26	68	80	30.00	30.00	SW.	Moderate		Cloudy.	Clear.
	27	68	82	30.00	30.00	SW.	do		Cloudy.	Clear.
	28	72	77	30.00	30.00	SW.	do	.40	Cloudy.	Rain.
	29	70	80	30.00	30.05	NE.	do		Cloudy.	Par cloudy.
	30	71	82	30.05	30.00	E.	do		Cloudy.	Clear.
	31	72	86	29.94	29 80	W.	do		Par. cloudy.	Clear.
		67.32	78.36	29.92	29.92			7.81		

Thermometer. Maximum 86 on 31st. Minimum 60 on 2nd. } Mean, 72.34

Barometer. Max. 30.25 on 4th. Min. 29.70 on 15th. } Mean, 29.92

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JOURNAL

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OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

DECEMBER, 1843.

Civil Engineering.

Cost of Transportation on Railroads. By CHARLES ELLET, Jr., C.E.

(Continued from Page 324.)

Repairs of Engines and Cars.

It is the custom of many companies to publish the cost of repairs of their cars and engines in a single item, so as to make it impossible for the reader to determine, from their accounts, what portion of the bill was created by the engines, or the difference between the repairs due to different sorts of cars; but still an industrious investigation of the subject gives us facts enough to estimate these separate items for ordinary cases, with all desirable accuracy. I have stated in a former paper that the repairs of burthen cars are worth, on the average, 4½ mills per ton per mile; and that the repairs of the engines averaged, during the year 1842, *seven* cents per mile run. I have also observed that the repairs of passenger cars vary from three-fourths of a mill to a mill and a half, and sometimes exceed 2 mills per passenger per mile. If these facts—all of which enter into the formula which I have offered for the determination of the aggregate annual expenses of a railroad company—be well established, they will not only stand the test of trial for the aggregate, but they will apply in detail. Not only should the formula for determining the aggregate expenses be correct, and correspond with actual results—as we have seen—but the separate items of which it is composed, must, likewise, bear the test, and give results in agreement with the average results of experience.

It is not pretended that a formula could be offered which would show the exact cost of every item of every company for every year—because the actual expenditures due to each item fluctuate from year to year; but it is maintained that these fluctuations are above and below a certain average line, from which they may depart towards

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either side for a certain time, but to which, and beyond which, on the opposite side, they are as sure to come as the pendulum is sure to approach the vertical in its vibrations. Although it was not my intention to enter so minutely into these details, probably more confidence will be yielded to my statements when the data on which they are founded are presented. These data, for the repairs of engines, are exhibited in the following

TABLE.

Name of Roads.	Year	Miles run by engines.	Cost of repairs of engines.	Repairs per mile run.	Remarks.
Philada. Wilm. & Balt.	1842	177,859	$ 17,071	9.6Cts.	Old Road.
Western Road,	1842	397,295	24,177	6.1	New road.
Georgia Road,	1842	152,873	16,155*	6.7	Ordinary & extraord'y repairs & improvem't.
Balt. & Susquehanna,	1842	128,349	7,193	5.6	New road.
Utica and Schenectady,	1842	150,000	10,346	6.9	Passenger business.
Baltimore and Ohio,	1841	299,617	20,640	7.0	Old roads in good condition.
Baltim'e and Washing'n,	1842	95,817	7,973	7.2	
Philada. & Columbia,	1842	261,744	21,915	8.4	Generally frei't business.
Boston and Providence,	1842	112,805	7,257	6.5	Old roads in good condition.
Baltimore and Ohio,	1843	509,765	35,941	7.0	
Wash. and Baltimore,	1843	96,716	6,714	7.0	
		2,382,840	$ 169,380	Avr. 7.1	

This table exhibits the cost of repairs of engines which have traversed a space of 2,382,840 miles; and shows that the average is within one-tenth of a cent, per mile run, of the mean value at which I had stated it. It is my impression, however, that the average on these same roads will be greater for the year 1843.

Now, if we call N the number of miles traveled by the locomotive engines; T the number of tons of freight carried one mile; and P the number of passengers carried one mile, the average aggregate cost of repairs of passenger and burthen cars, and locomotive engines, will be shown, very nearly, by the formula,

$$\frac{7N}{100}+\frac{4.5T}{1000}+\frac{P}{1000}.$$

By expressing the cost of repairs in this way, we are able to determine, at once, the expenses of repairs for an entire train composed of either description of cars, or of both sorts, and in any proportions.

Although this, and all my other, estimates might be much strengthened, by bringing forward facts resulting from former experience, I prefer, with one or two exceptions, to limit my examples, on this occasion, to those works of which I have obtained authentic information for the year 1842. Of course, I exclude those lines which have been so recently completed, as to require no repairs at all for cars.

The following table presents the number of miles run by locomotive engines, and the number of tons and passengers carried one mile on eight railroads for the year 1842, and two for 1843—which have been

* This Company have added to the usual division of their expenses into ordinary and extraordinary repairs, the new classification of "improvements to engines;" not being able to conceive that a small stock of engines could run 153,000 miles, and be materially improved by it, I regard these "improvements" as *expenses*.

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recently published;—and in the two last columns will be seen the actual expenses of repairs of cars and engines, and the expenses of the same computed by the formula.

TABLE.

Name of Road.	Year	Miles run by engi's.	Tons carried one mile.	Passengers carried one mile.	Actual cost of repairs.	Comput'd cost of repairs.
Petersburg Road,	1842	131,160	1,342,000	976,000	$ 16,513	$ 16,196
Boston and Providence,	1842	120,000	890,400	4,919,418	13,506	17,326
Baltimore and Ohio,	1841	299,617	3,647,093	2,495,911	45,534	39,881
Baltimore and Ohio,	1842	334,519	3,985,425	2,738,779	44,568	44,189
Baltimore and Ohio,	1843	509,765	7,109,310	6,062,455	62,862	73,738
Baltim. and Washington,	1843	96,716	805,429	2,646,719	17,453	14,801
Baltimore and Susque'a.,	1842	128,349	1,610,000	1,165,000	13,370	17,390
Balt. and Washington.	1842	95,817	877,138	3,188,948	17,053	13,864
Utica and Schenectady,	1842	150,000		8,413,704	18,842	18,914
Boston and Lowell,	1842	143,607	2,442,102	4,675,294	28,816	25,716
Georgia Road,	1842	152,873	1,475,000	1,770,000	19,899	19,107

On inspecting this list we will observe that the actual charges on some of the roads are a little above, and on others a little below, the indications of the formula—but that the deviations are in no instance too wide to render the rule, as far as it goes, a safe test of the value of an investment. The actual cost on the Baltimore and Ohio Railroad falls considerably below the computed cost for the year 1843. In 1842 the agreement was very close, and in 1841 the result was nearly as much above as that of 1843 is below the rule. Indeed, in 1841 the sum of $ 9,766 was expended for *new* burthen and passenger cars, in addition to the $ 45,534 charged to repairs of cars and engines. The aggregate expenses for repairs of cars and engines, on that work, for the three years amounted to $ 152,964—and the expenses calculated by the formula to $ 157,808. If we add the sum paid for *new cars*, to the actual cost of repairs, the actual expenses, for the three years, will be $ 162,730, or 3 per cent. above the computed expenses.

The formula simply exhibits what it is intended to show—the average for a succession of years. I do not include the Boston and Worcester road in this table, because the result on that work is entirely anomalous. For previous years the agreement between the calculation and expenses was sufficiently close; but in 1842 there was a material increase of business, an extraordinary reduction in the expense of repairing the cars and engines, and a simultaneous augmentation of the capital—or charge for construction—of $ 390,000. I am obliged to suppose that new cars and engines were added to the line, and that a portion of the business was performed by new stock.*

We may now pass to another very important division of railroad expenses, which are usually, though very improperly, denominated "extraordinary expenses." I refer chiefly to the

Wear of Iron Rails.—There is, perhaps, no subject of interest to

* The cost of repairs of locomotive engines for this road, for the year 1841, was 9½ cents per mile run, and in a space of seven years, from 1835 to 1841 inclusive, the engines performed an aggregate distance of 850,809 miles, at an aggregate cost of $ 84,183; or within a fraction of 10 cents per mile run. The repairs of cars are fluctuating, but the average is in accordance with the formula. This road is not an exception to the rule, though the formula does not apply for the year 1842.

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iron. Instead of attempting to find some correct and rational measure of this wear, the public, and in a great measure, the profession also, have persisted in regarding the visible destruction of the iron on roads which have been some years in operation, as a consequence of the inferior quality of the particular specimen, or of the inadequate strength of the particular pattern. It is the custom to say that the mashed and splintered iron of the Camden and Amboy, and Columbia roads was bad; but no argument has ever been adduced to show that good iron, in the same situation, and subjected to the same sort of treatment, would do better.

So long as railroads happened to occupy positions where they would be used for the mere conveyance of the travel, and a few thousand tons of goods, between adjacent cities, the durability of iron was a question of subordinate interest. An engineer could be satisfied that his rail would last 10 or 20, or 30, years, and could generally count on a sufficient increase of business consequent on the increase of population, to compensate for its destruction in that space of time. But railroads are now projected to take the place of important canals, and to furnish the means of transport for the heavy products of the earth at exceeding low rates. The question assumes, therefore, another aspect. The trade of the Erie canal in New York, and of the Schuylkill Navigation in Pennsylvania, may be estimated at 700,000 to 1,000,000 tons per annum; and there is no railroad in the United States worked by steam power, which accommodates more than the one-ninth, or one-tenth, of this amount, with the exception of the Reading railroad, which has not yet been long enough in operation to yield any useful practical results.

The common half-inch flat bar, under ordinary circumstances, is adequate to the transportation of about 150,000 tons of freight. Such a bar on the Petersburg road, where the freight amounts to some 25,000 tons, would resist the wear of six years' business; but if one year's trade of the Schuylkill canal were poured along it, the iron part of the track would need entire renewal *six times in one year.*

The same remark is applicable to any of the same sort of wooden roads in the country. They would all bear about 150,000 tons net, drawn at the usual speed of ordinary freight engines, but would be completely destroyed by about *five weeks' business* of the Schuylkill Navigation, in the season of active trade.

It must be admitted that we have not yet sufficient data for estimating, with entire certainty, the probable durability of many varieties of rails. We have, however, data sufficient, if we use it properly, to make a much nearer approximation than is generally supposed to be practicable. The durability of the half inch plate rail can be determined with all desirable accuracy, and we can judge from analogies, which the problem presents, the probable wear of other patterns. Great errors have been committed in the consideration of this subject, by overlooking the fact that the progress of the wear is rarely ascer-

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annual charge for iron is very small, because, in general, the track does not appear to give way until it is nearly unfit for use. When repairs really commence, the destruction is so far advanced that the iron must be renewed; and if the directors assert, as they usually do, in their next report to the stockholders, that experience has shown that the original iron was very bad, and has all been crushed, the explanation is satisfactory, and the cost of the new iron is forthwith charged to the account of construction.

We accordingly find, in looking through the reports of railroad companies, that the average annual increase of capital, generally exceeds the dividends even of the most successful enterprizes; and *there is not now to be found in the country a single road which has renewed its iron out of the proceeds of transportation.* While the trade continues to be small, and this extraordinary outlay is needed but once every 6 or 8 years, the self-deception can be practiced with considerable success. But there are now works constructed which are intended for a very great business, and which will reduce the extraordinary charge for renewal of iron down to a very ordinary circumstance. The Reading Railroad is contemplated for the conveyance of the present trade of the Schuylkill Canal—from seven to eight hundred thousand—and which will very soon reach one million of tons—and should the experiment succeed, *the cost of iron will be more than equal to the entire renewal of a single track every year.* The question of wear, is, therefore, of immense importance, and can no longer be lightly disposed of by companies of this class.

This, as every other item of railroad expenses, is subject to a certain law, which must be recognized before we can make any effectual progress in our investigation.

The destruction of iron depends on the grades of the road, on the tonnage, and on the travel. Every ton of freight that passes produces a certain amount of injury; every passenger car and every passenger does some injury, and every engine that traverses the line produces its share of mischief; but the number of engines that traverse the road, in conveying a given amount of tonnage, depends on the limiting gradient—and, consequently, the destruction of iron, *cæteris paribus,* is greatest on those roads of which the grades are most unfavorable to the useful effect of the power.

If we call N the number of miles traveled by all the engines on the line; T the number of tons net conveyed one mile; and P the passengers conveyed one mile, for one year, then

$$aN+bT+cP,$$

will be the form of the expression which represents the amount of injury which the iron has sustained—a, b, and c, being constants to be supplied by experiment. It is assumed, of course, that the weight and form of the rail, as well as the weight, construction, and velocity of the engines, are uniform.

The point, now, is to determine the values of the coefficients, a, b, and c. For this purpose I take, in the first place, a road on which

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engines are not used, and but few passengers are conveyed. The wear of iron on such a road gives us the value of b, or the injury done by the tonnage.

There are two works of this description of which we can find published reports, and which have been long enough in activity to destroy a portion, or the whole, of their iron.

The *Chesterfield Railroad*, in Virginia, constructed with a flat bar, and using horse power and light cars, has required, for some years past, about $200 per mile for new iron, to replace that which is destroyed by the passage of an average trade of about 50,000 tons of coal. The destruction is here equivalent to *four mills* per ton per mile.

The *Mine Hill and Schuylkill Haven Railroad* was originally constructed with a flat bar, and six miles in length of the road had been renewed with a heavy edge rail, before 400,000 tons had passed along it. Assuming the value of the flat bar at $60 per ton, or $1200 per mile, which is below its present value, and that the iron was worn out by 400,000 tons, the result will be three mills per ton per mile. But this road is provided with a double track, and the track which was destroyed was not used by the ascending cars.

The injury produced by the empty cars is certainly more than one-third of that effected by those which are loaded; and the result on this road, therefore, corresponds very closely with the previous example. The wear then obviously will not be less than 4 mills on a road sustaining locomotive power—where the velocity is much greater than on the Chesterfield and Mine Hill roads.

I will not, therefore, be above the mark in assuming $b=4$ mills.

The flat bar on the *Petersburg Road* may be considered to have been worn out in six years, by use which was equivalent to 12,000 trips of locomotive engines; 130,000 tons of freight, and 100,000 passengers carried over each mile. If we consider the injury caused by cars carrying 5 passengers, equal to that produced by those carrying 1 ton of freight, and the value of this iron equal to $1200 per mile, we shall have

$$b\,\mathrm{P}+c\,\mathrm{T}=\$600$$

for the damage due to the freight and passengers.

The remaining sum of $600 is the destruction produced by the 12,000 miles run by the locomotive engines; whence we have

$$a=\frac{60.000}{12,000}=5 \text{ cents};$$

or 5 cents for the injury done by the passage of the locomotive engine over every mile of the road.

We obtain, then, from this procedure, $a=5$ cents; $b=4$ mills; and $c=\frac{4}{5}$ mill, and for our formula

$$\frac{5\,\mathrm{N}}{100}+\frac{4\,\mathrm{T}}{1000}+\frac{4\,\mathrm{P}}{5000}.$$

If these values be correct they will apply to any other similar case.

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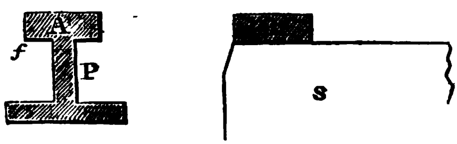
The first iron used on the South Carolina Road, was destroyed in less than six years—after it had borne about 130,000 through tons, and 120,000 through passengers, and the locomotive engines had made 10,000 through trips. The formula will give for this case,

$$\frac{10{,}000 \times 5}{100} + \frac{130{,}000 \times 4}{1000} + \frac{120{,}000 \times \frac{4}{5}}{1000} = \$\,1{,}116$$

for the destruction of the iron per mile. This is, no doubt, very near the true value of the first iron used on that road, estimated at the present prices.

There are several other roads, of both descriptions, for which similar computations might be made, and which would confirm the estimate—and I shall take occasion, at a subsequent period, to present much data of the same character in a tabular form. But without discussing this branch of the subject further, at present, it may be stated in round numbers, that the average destruction of the half inch plate rail, caused by engines, freight, and passengers, is equal to about 8 *mills per ton net per mile;* and by comparing the above expression of the wear of the rail, with that previously obtained for the wear of the cars and engines, we will perceive that they possess very nearly the same value—or that the injury done to this iron, by the passage of a train, is but about 10 per cent. less than the wear and tear of the engine and cars composing the train.

In the application of this formula, however, the fact is not to be overlooked, that it is derived from the destruction of the plate rail, and is intended only to be applied to that description of road. *The destruction of any form of* T *or* H *rail, which I have yet seen, will be greater.* It is true that the expenses of maintenance for some new roads, provided with heavy iron, are yet very light, and they will possibly continue to be light until they have carried from three to five hundred thousand tons of freight—when, if the rail is still in existence, they will be very heavy.



It requires but little experience, and no speculation, to bring us to this conclusion. Let us take the two patterns, fig. 1, and fig. 2, for the purpose of illustration. Fig. 1, is a common form of edge rail, of 60 pounds per yard, of which the head, or upper table, A, weighs 20 pounds. Fig. 2, is a common plate rail, 2½ inches wide, by ⅞ of an inch thick, which also weighs about 20 pounds.

This flat bar is supported along its whole length and breadth by the wooden string, S, and the edge rail is supported only in the centre by the vertical stem, P. Is there now any reason why the unsupported flanch, *f*, should do more service than the supported flat bar, B? The vertical stem and base of fig. 1 never wear out; it is the head of that rail which is crushed and rolled to pieces. When the rail

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bruised and split, the whole rail is rendered useless—and when the rail is ruined, 60 pounds of iron per yard, are lost to the company. The flat bar will bear just as much—indeed, being supported, a little more—hammering, and when it is destroyed, but twenty pounds are lost. Besides it may be welded when broken, the ends may be "upset," and restored when split; new holes, when necessary, may be punched, and it can be returned to the road until the lamination and splintering throughout render it wholly unfit for useful service.

But it is not my intention to speculate here on the relative merits of rails. The present object is to adduce facts and conclusions based on observation of many roads of various descriptions, in relation to the destruction of such rails as are ordinarily adopted. I know that my opinions on this head are not those of the public, nor of many professional gentlemen of much experience; but I believe they are, nevertheless, correct, and I therefore submit them to a test which will speedily be applied, and by which this question will be most conclusively settled.

The rails of the Reading road are, by common consent, acknowledged to be good; the pattern is considered, by the advocates of edge rails, to be unexceptionable; and the mode of manufacture adopted—that of making the lamina horizontal—is considered to render them almost proof against wear.

In regard to these rails—with all their merits, and all their superiority—I affirm,

1st. That they will not withstand the rolling of the trade of the Schuylkill valley for one year.

2nd. That before 800,000 tons of coal have passed down, and the empty cars have been returned on them, the present track will be entirely unfit for safe usage.

3rd. That it will cost from 50 to 75 cents to replace the iron which is destroyed by each ton of coal that descends from Pottsville to Richmond, on the present track. And,

4th. That before next August, if the company succeed in obtaining the trade which they desire, this rail will be pronounced *too light* by the very parties who now think it will last forever.

The fault, however, is less in this particular rail than in *iron*, which is not tough enough for such usage at such prices.

I know that the *Providence road* will be adduced as evidence against me, where the road has been some six years in use, and the iron is yet sound; but the Providence road actually passes but 30,000 tons per annum on a single track, and must yet stand 25 years before it can do one year's business of the Schuylkill canal.

The *Georgia road* may, perhaps, be quoted as evidence, where *experience*, they say, has demonstrated, beyond all question, the ability of railroads to compete with canals, for the conveyance of heavy freight; but the Georgia railroad has been less than three years in operation, and has *not yet carried as much freight as has sometimes passed along the Schuylkill canal in three days.* Pour the trade of the Schuylkill, or Erie, canal, on parts of that road, with

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such engines as would be needed for its conveyance, and the track would be crushed in less than four weeks.

The *Boston and Lowell road* will be quoted. This road has not yet carried, in the eight years of its existence, an aggregate tonnage equal to the Schuylkill trade—and that tonnage has been sufficient for the destruction of the first track of edge rail, and the company are now, and have been for some time, using the second and third tracks.*

The *Camden and Amboy road* was originally provided with a "permanent" track. The aggregate trade has not yet reached 300,000 tons net—the reader who feels any interest in such matters can cross the Delaware to Camden, and examine the old rails, and form his own conclusions; he will then be able to judge whether these have given out because they are too weak, or because the material, in this form, is inadeqate to a much greater effort.

In *England,* however, it is contended, people have more experience. The *best* experience there, is that of the Liverpool and Manchester Railroad, a work which was opened to public use in the fall of 1830. This road was at first supplied with two tracks of edge rails, weighing 35 pounds per yard. The rail answered very well until the fall of 1833, when the work had passed about 300,000 tons on each track, at which period £150 were expended for *new rails.* In the next half year, before they had transported 350,000 tons, an additional outlay of 3000 pounds sterling was required for new rails, and the adopted pattern was pronounced *too light* for the service. A rail weighing 50 pounds per yard was next tried, and subsequent experience showed that that also was *too light.* A new pattern was then projected, weighing 62 pounds per yard, and forthwith submitted to the same rough usage. The trade on this road is great, and soon tests the merit of a fancy. This pattern was also found inadequate, and another, weighing 70 pounds per yard, was fixed upon, which was, *last year,* regarded as the pattern rail. I have not yet heard how it wears, but one year more will test its strength on that road, where there is really a heavy trade, although the net tonnage does not reach one-half, nor much exceed one-third, of the average trade of the Schuylkill, or Erie, canals. I do not believe that either pattern would resist the action of one year's business of one of those works, if it were confined to a single track.

I trust that those who have made observations on this interesting subject, will communicate them for publication in this journal. If there be an edge rail in the United States, which has sustained the passage of a million of tons of freight,† conveyed by locomotive engines, it could not but be regarded as a most encouraging circumstance, and its history ought to be known; such a rail—weighing 60 pounds per yard—would show the practicability of reducing the average cost of

* It is proper to say that the rails of this road were taken up after six years' use, because they were too weak; but we never meet with rails that are *strong enough* after they have sustained the passage of 600,000 tons.

† In a report on Herron's cast-iron rails laid before the Committee on Science and the Arts of the Franklin Institute, about two years ago, I stated that no road in the United States had yet sustained one million of tons of freight: I have not yet heard of such an instance.

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this item for such rails down to 6 mills per ton per mile; and, therefore, below any result which I have yet been able to obtain. My impression is, from the comparisons of the actual destruction which I have been able to make, that its value may be reduced, by the adoption of a suitable flat bar, and a moderate speed, to 3½, or 4, mills per ton per mile.

(To be continued.)

Experiments on Water-Wheels, having a vertical axis, called Turbines. By Arthur Morin, C. A., P. M. S. A., &c. &c.

(Translated from the French, by Ellwood Morris, Civil Engineer.)

[Continued from Page 302.]

XXV.

Observations on the emission of the water by the openings of the Turbine.

It remains for us to make known some results of particular observations on the mode of gauging adopted at Müllbach, for estimating the expenditure of water made during the experiments.

Our design in uniting these results was to know if it were possible to determine, for each lift of the sluice-gate, the value of the coefficient of the discharge made by the openings of the turbine, in order to be able to calculate directly the volume of water vented by these orifices, in cases where it would not be possible to establish direct modes of gauging; but we must, nevertheless, premise, that not having been able to give to the means of observation sufficient precision, we have not pretended to arrive at results, comparable for exactness, with those which have been obtained either at Metz, or Toulouse, and that we solely propose to establish the approximate values, and to examine the influence of the velocity of the wheel, and of the size of the openings. Knowing, for each experiment, the volume of water discharged, the lift of the sluice-gate, the sum of the horizontal breadths of the orifices, or the shortest distances between the curved guides of the sluices, equal to (1.56 m.) 5 $\frac{12}{100}$ feet, we have compared the theoretical expense, made under the known difference of the upper and lower levels, to the effective expense, (or actual discharge of water, and we have by it deduced the corresponding value of the coefficient of the discharge; [or that constant number, which, multiplied by the known areas of the openings, and by the theoretical velocity of the water due to the fall, gives the actual discharge.—Tr.]

The results of this comparison are recorded in the following table, which shows at once that the coefficient increases with the velocity of the wheel; this is a consequence of the action of the centrifugal force diminishing the pressure exerted below in the orifices, and tends consequently, to augment the discharge; but as the immediate results of the experiments do not offer all the regularity desirable for observations on the emission of the water, we have sought another way to unite them, and by it to deduce a kind of general law, by representing them by the curves, Figs. 9, 10, 11, 12, and 13, Plate II, of which the abscisses are the number of turns of the wheel in a minute, and the ordinates the coefficients of the discharge deduced from calculation.

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metre; circumference, inner circle = 5.024 *metres.*

Number of the experiments.	Sum of the areas of the orifices.	Lift of the sluice-gate of the turbine.	Charge of water, or difference of the levels, above and below.	Number of turns of the wheel in one minute.	Discharge of water in a second. Theoretical.	Discharge of water in a second. Actual.	Coefficient of the discharge.	Theoretical velocity of the water per second.	Velocity of the wheel at the inner circle, per second.	Ratio of the velocity of the wheel at the inner circle, to the theoretical velocity of the water per second.
	Sq. m.	Metres.	Mtrs.	No.	M. cub.	M. cub.		Metres.	Metres.	
1	0.078	0.050	3.552	72.	0.650	0.623	0.957	8.35	6.02	0.721
2	"	or	3.547	67.9	0.650	0.628	0.957	8.35	5.68	.680
3	"	.050	3.560	64.8	0.651	0.623	0.956	8.36	5.42	.648
4	"	.330	3.580	63.1	0.654	0.623	0.953	8.38	5.28	.630
5	"	10-66ths	3.580	60.0	0.654	0.523	0.953	8.38	5.02	.600
6	"	of whole	3.565	57.6	0.651	0.623	0 956	8.36	4.82	.577
7	"	height	3.555	55.3	0.650	0.611	0 940	8.35	4.63	.554
8	"	0.333 m. or	3.565	53.3	0.651	0.611	0.938	8.36	4.46	.533
9	"	15-100ths	3.580	50.7	0.654	0 611	0.935	8.38	4.24	.506
10	"	of 0.333 m.	3.585	47.6	0.654	0.610	0.933	8.38	3.94	.470
11	"	or 1-100th	3.621	43.9	0 657	0 610	0.930	8.43	3.67	.435
12	"	of the cir-	3.621	40.9	0.657	0.610	0.930	8.43	3.42	.406
13	"	cumfer'ce	3.650	37.5	0.660	0.610	0.925	8.46	3.14	.371
14	"	of inner	3.680	34.25	0 661	0.610	0.923	8.50	2.86	.337
15	"	circle.	3.703	31.	0.665	0.623	0.935	8.52	2.59	.303
16	"		3.725	28.1	0.666	0.623	0.933	8.54	2.35	.275
17	"		3.730	26.85	0.667	0.623	0.931	8.55	2.24	.262
18	"		3.750	21.7	0.668	0.623	0.935	8.58	1.82	.212
19	0.1404	0.090	3.224	75.	1.112	1.156	1.039	7.95	6.28	.790
20	"	or	3.199	69.	1.109	1.087	0.990	7.92	5.77	.729
21	"	.09	3.208	65.	1.110	1.101	0.993	7.93	5.45	.687
22	"	.333	3.210	61.6	1.110	1.071	0.996	7.94	5.15	.649
23	"	27-100ths	3.196	59.2	1.109	1.071	0.965	7.93	4.96	.625
24	"	of whole	3.177	56.	1.105	1.071	0.972	7.90	4.69	.594
25	"	height	3.190	52.	1.109	1.036	0.936	7.91	4.35	.550
26	"	0.333, or	3.190	49.2	1.109	1.016	0.917	7.91	4.12	.521
27	"	18-100ths	3.207	45.25	1.119	1.016	0.916	7.94	3.79	.477
28	"	of circumf.	3.207	41.	1.110	1.016	0.916	7.94	3.43	.432
29	"	of inner	3.213	37.2	1.110	1.008	0.908	7.94	3 11	.392
30	"	circle, or	3.225	35.	1.112	1.008	0.906	7.95	2.93	.369
31	"	27-100ths	3.265	32.5	1.120	0.971	0.869	8.00	2.72	.340
32	"	of whole	3.305	29 5	1.177	0.971	0.827	8.05	2.47	.307
33	"	height.	3.295	27.5	1.175	0.976	0.831	8.04	2.30	.286
34	0.2340	0.150	3.164	99.5	1.840	1 881	1.022	7.88	8.33	1.057
35	"	or	3.164	92.0	1.840	1.786	0.972	7.88	7.70	.977
36	"	45-100ths	3.150	90.0	1.839	1.781	0.960	7.86	7.54	.959
37	"	of whole	3.153	83.5	1.839	1.751	0.954	7.86	6.99	.890
38	"	height;	3.110	78.5	1.825	1.747	0.957	7.81	6.57	.841
39	"		3.070	73.0	1.815	1.766	0.974	7.76	6.11	.787
40	"		3.070	69.0	1.815	1.666	0.917	7.76	5.77	.744
41	"		3.075	63.0	1.815	1.641	0.905	7.76	5.27	.679

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No. of the experiments.	Sum of the areas of the orifices.	ift of the sluice-gate of the turbine.	arge of water, or difference of the levels, above and below.	umber of turns of the wheel in one minute.	Discharge of water in a second.		Coefficient of the discharge.	eoretical velocity of the water per second.	locity of the wheel at the inner circle per second.	tio of the velocity of the wheel at the inner circle, to the theoretical velocity of the water, per second.
					Theoretical.	Actual.				
	Sq.Mt.	Metres.	Mtrs.	No.	M. cub.	M. cub.		Metres.	Metres.	
42	0.2340	0.150	3.035	58.25	1.800	1.586	0.883	7.71	4.87	.631
43	"	or	3.085	52.0	1.820	1.576	0.867	7.78	4.35	.559
44	"	30-1000ths	3·085	48.0	1.820	1.561	0.859	7.78	4.02	.517
45	"	of the cir-	3.085	44.0	1.820	1.526	0.840	7.78	3.68	.473
46	"	cumference	3.380	45.3	1.900	1.652	0.872	8.14	3.79	.466
47	"	of the inner	3.272	38.0	1.873	1.528	0.817	8.01	3.18	.397
48	"	circle.	3.400	38.5	1.909	1.528	0.801	8.17	3.22	.394
49	"		3.405	34.4	1.909	1.528	0.798	8.17	2 88	.353
50	0.3120	0.200	3.020	104.	2.402	2.053	0.854	7.70	8.70	1.130
51	"	or 60-100ths	3.045	103.	2.404	2.033	0.860	7.73	8.62	1.115
52	"	of the whole	3.080	101.5	2.422	2.025	0.847	7.77	8.49	1.092
53	"	height, or	3.120	95	2.443	2.003	0.822	7.83	7.95	1.015
54	"	40-1000ths	3.170	90.4	2.464	1.993	0.809	7.89	7.57	.959
55	"	of circum-	3.190	87.1	2.470	1.951	0.80,7	7.91	7.29	921
56	"	ference of	3.203	82.8	2.472	1.913	0.766	7.93	6.93	.874
57	"	the inner	3.240	80.	2.490	1.913	0.768	7.97	6.70	.841
58	"	circle.	3.255	75.	2.491	1.913	0.768	7.99	6.28	.786
59	"		3.270	70.	2.500	1.913	0.767	8.01	5.86	.731
60	"		3.305	67.6	2.509	1.913	0.765	8·05	5.66	.703
61	"		3.310	67.1	2.512	1.913	0.759	8.06	5.62	.697
62	"		3.310	63.	2.512	1.872	0.747	8.06	5.27	.654
63	"		3.335	58.	2.522	1.872	0.742	8.09	4.86	.601
64	"		3.306	50.6	2.509	1.812	0.722	8.06	4.24	.526
65	"		3.286	48.5	2.502	1.812	0.724	8.03	4.06	.505
66	"		3.321	44.	2.520	1.812	0.720	8.07	3.68	.456
67	"		3.610	100.	2.622	2.173	0.829	8.42	8.27	.994
68	"		3.650	97.	2.642	2.082	0.790	8.46	8.12	.960
69	"		8.560	91.	2.607	2.143	0.805	8.36	7.62	.912
70	"		3.475	87.	2.570	2.083	0.815	8.25	7.28	.882
71	"		3.300	80.	2.620	2.061	0.788	8.04	6.69	.832
72	"		3.250	72.	2 493	1.983	0.796	7.99	6.03	.755
73	"		3.230	67.	2.483	1.943	0.782	7.96	5.61	.706
74	"		3.358	62.1	2.715	1.933	0.710	8.11	5.19	.640
75	"		3.343	57.1	2.710	1.908	0.702	8.10	4.78	.590
76	"		3.393	54.	2.548	1.863	0.733	8.15	4.52	.554
77	"		3.398	49.4	2.542	1.863	0.733	8.16	4.12	.505
78	0.4212	0.270	2.990	90.6	3.230	2.523	0.782	7.66	7.58	.989
79	"	or 81-100ths	3.070	87.	3.207	2.523	0.773	7.76	7.28	.938
80	"	of the whole	3.170	84.6	3.320	2.442	0.737	7.89	7.08	.897
81	"	height, or	3.180	77.25	3.240	2.442	0.757	7.90	6.47	.819
82	"	54-1000ths	3.310	69.	3.540	2.442	0.691	8.06	5.77	.716
83	"	of circum. of	3.475	66.1	3.470	2.523	0.730	8.25	5.54	.671
84	"	inner circle.	3.390	61.5	3.430	2.445	0.712	8.16	5.14	.630

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Fig. 7.

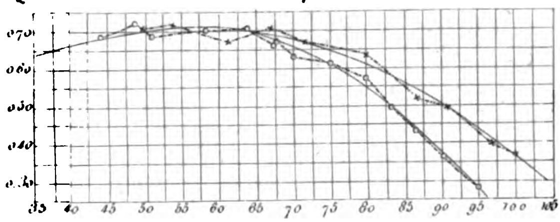


Fig. 8.

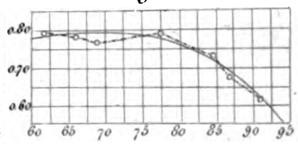


Fig. 9.

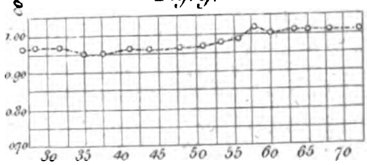


Fig. 10.

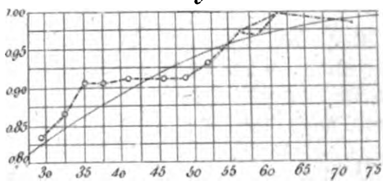


Fig. 11.

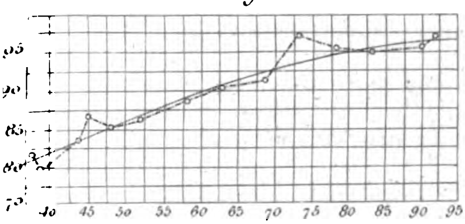


Fig. 13.

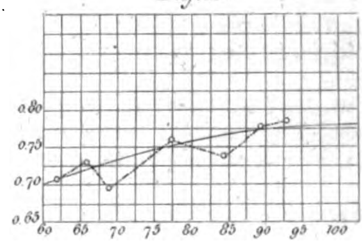
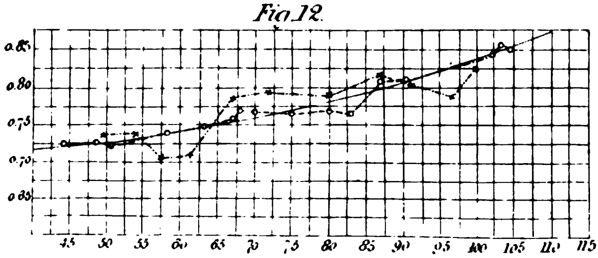


Fig. 12.



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[NOTE.—The three last columns of this table have been added by approximation, so as to show, nearly, the relative velocities of the wheel at the inner circle, and that which theory assigns to the water under the several falls stated.—Tr.]

XXVI.

Consequences of the results contained in the preceding table.

This table, or rather an examination of the foregoing curves, figs. 9 to 13, shows:—

1. That for the small lift of sluice-gate of (0.050 m.) $\frac{16}{100}$ of a foot, the coefficient of the discharge, or which comes to the same, the expense of water made in a second, by the orifices of the turbine, increased a little, with the velocity of the wheel, but so slowly that its mean value, from 20 unto 55 turns in a minute, is equal to about 0.93, and that it rises gradually with the velocity up to the value 0.96, when it reaches about 65 turns in a minute.

2. That at a lift of sluice-gate of (0.09 m.) $\frac{29}{100}$ of a foot, the coefficient of the discharge, which is about 0.93, at the velocity of 25 turns in a minute, rises very rapidly with the velocity, and reaches with about 75 turns in a minute the value 1.039, which shows that the effective discharge will be greater than the theoretical discharge.

3. That at a lift of sluice-gate of (0.150 m.) $\frac{49}{100}$ of a foot, this coefficient, which had only the value of 0.80, at the velocity of 34 turns in a minute, reached, and also exceeded that of *unity*, at the velocity of 99½ turns in a minute.

4. That at a lift of sluice-gate of (0.200 m.) $\frac{65}{100}$ of a foot, this coefficient, which had only the value of 0.72, at the velocity of 45 turns in a minute, reached that of 0.85, at the velocity of 102 turns in a minute.

5. Finally, that at a lift of the sluice-gate of (0.270 m.) $\frac{88}{100}$ of a foot, the same coefficient which had the value of 0.71 at the velocity of 75 turns in a minute, reached that of 0.76 at the velocity of 106 turns in a minute.

From these it results evidently that the discharge of water made by the turbines, increases with their velocity of rotation, and, moreover, as the effect of the centrifugal force to which this increase is due, depends on the proportions of the wheel, it follows that we shall be able to establish, in each case, a discussion of these proportions, by comparing the effects to the cause.

XXVII.

Influence of the height of the Lift of the Sluice-gate on the discharge.

The curves of the coefficients show us also that these numbers, at equal velocities, are incessantly diminishing in proportion as the lift of the sluice-gate increases. We can verify this by examining the following table, in which we have combined the relative values at the different velocities and lifts of the sluice-gate, deduced from the mean trace of these curves.

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of the wheel per minute.	for the following lifts of sluice-gate.			
	0.090 m.	0.150 m.	0.200 m.	0.270 m.
40	0.905	0.820		
50	0.945	0.862	0.728	
60	0.975	0.900	0.743	
70	0.995	0.930	0.762	0.706
80		0.953	0.784	0.723
90		0.968	0.812	0.746
100		0 980	0.840	0.767

[NOTE.—We have not comprised in this table the coefficients relative to a lift of the sluice-gate of 0.050 m., because under the ratio sought, it did not admit of showing the diminution which is here the question.]

This diminution of the coefficient of the expense of water, in proportion as the lift of the sluice-gate augments, belongs evidently to the disposition of the orifices, and seems to us easy to explain, from the facts known of the emission of water by ajutages of many forms.

In effect, from the manner in which the orifice is disposed, the two contiguous curves forming the vertical walls give it, in this sense, a form analogous to that of casks, where the ajutages converge; the lower side is found in the prolongation of the bottom, and the upper side is the lower one of the cushion of wood that rises with the sluice-gate. It follows that for small lifts of sluice-gate the water issues by a true ajutage conic laterally, and with faces parallel on the vertical sides, and for which the contraction, at the entrance, is nearly null. It is not then astonishing that in that case the coefficient of the discharge attains a value equal, and even superior, to 0.90, since we know (Traité d'Hydraulique de M. d'Abuisson, p. 54,) that for conic converging ajutages, this number acquires, according to the inclination of the sides of the cone, similar values.

In proportion as the lift augments, the influence of the cushion for diminishing the contraction of the entrance of the ajutage, becomes less, because in spite of the rounding of its lower border, it has not the exact form of the fluid vein, and as the volume of water expended augments, the velocity in the interior pipe becomes greater, in consequence of the convergence of the fillets near the orifice.

The cushion has, moreover, only (0.170 m.) $\frac{56}{100}$ of a foot mean thickness in the direction of the length of the ajutage, and when the lift of the sluice-gate reaches, or exceeds, (0.150 m.) $\frac{49}{100}$ of a foot, we see that this ajutage approaches, in advantage, to those which have contraction at the entrance, or of the orifices with contraction on the upper side solely.

The change of direction that the water suffers in descending the

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vertical pipe, to issue parallel to the bottom, occasions also a loss of active force, which ought to increase with the lift of the sluice-gate.

All these circumstances which concur to the same results, sufficiently explain, I think, the gradual diminution of the coefficients, and, as we have seen before, that this number, on the contrary, augments with the velocity of rotation, and that these two variations in opposite directions, depend upon the proportions of the wheel, we see that, in all experiments, or observations, on wheels of this species, it is indispensable to establish, for gauging the water expended, a stop-gate *above*, or better yet, *below* the wheel. It will be, moreover, always preferable to establish it below, because, on the one hand, the variations of level occasion much less error, and above all, less loss of time in regulating the level, and which we are able to appreciate, as we had to take at Müllbach, the volumes of water produced by the leakage, more or less great, of the reservoirs, and of the sluices.

We ought to remark that the experiments on the turbine of Moussay, have also shown that the coefficient of the discharge, diminished in proportion as the lift of the sluice-gate augmented, but that the increase produced by the centrifugal force, during the great velocities, did not there manifest itself in a notable manner; owing, perhaps, to this, that the wheel, having only a very little breadth, the action of this force there was much less sensible.

XXVIII.

Experiments on the Turbine established in the Mill of Lepine, Canton of Arpajon.

The account rendered of the session of the (French) Academy of Sciences of the 5th February, 1838, contains a series of experiments made by M. Dieu, Chief of Squadron of Artillery, and Inspector of the Gunpowder Manufactory of the Bouchet. We, from it, insert the results:

The gauge of the expense of water was made by means of a stop-gate placed *above* the wheel in the canal of supply, and forming a waste-board; and we have calculated the volume of water emitted by the formula,

$$Q = 0.406\,LH\sqrt{2gH}.$$

Floats placed above this waste-board, and above and below the turbine, served to measure the charge of water on the sill of the waste-board, and the total fall.

The *brake* was formed of a cast-iron muff, or collar, embraced by two pieces of wood which were placed on the shaft of the wheel, and continually wetted by a fillet of water which prevented the overheating of the surfaces, and kept them at a constant state of humidity. The other dispositions were also entirely analogous to those which we have before detailed.

The arm of the lever of the brake was (4 metres) $13\frac{12}{100}$ feet long, and the constant load was (0.625 kilogrammes) $1\frac{38}{100}$ pounds.

The results of the experiments are recorded in the following tables:

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Experiments on the Turbine of Lepine, near Arpajon, (Department of Seine-et-Oise.)

Nos. of the experiments.	Volume of water discharged in a second.	Total fall.	Theoret. Power of the motor.		Total load of the brake.	No. of turns of the wheel in a minute.	Useful effect measured by the brake.		Ratio of the useful effect to the theoretical power of the motor.
			No. kilog. lifted one metre per second.	No. horses-power.			No. of kilogs. lifted one metre in a second.	No. of horses-power.	
	M. cub.	Mtrs.	Kilog.	Hrs. pr.	Kilog.	No.	Kilog.	Hrs. pr.	
1	0.436	2.073	904.0	12.05	22.625	73.77	699.0	9.32	0.773
2	0.440	2.048	901.6	12.01	18.625	88.20	688.2	9.17	0.765
3	0.440	2.065	908.6	12.11	20.625	80.35	694.0	9.25	0.763
4	0.440	2.065	908.6	12.11	22.625	72.58	687.7	9.17	0.757
5	0.440	2.048	901.0	12.01	24.625	67.16	692.7	9.23	0.769
6	0.440	2.043	898.9	11.98	26.625	64.10	714.8	9.53	0.795
7	0.436	2.048	892.9	11.90	28.625	58.44	700.6	9.34	0.784
8	0.436	1.993	868.9	11.59	17.625	90.90	671.0	8.94	0.772
	3.508	16.383	7184.5	95.76	182.000	595.50	5448.0	73.95	6.175
Means.	0.438	2.048	898.0	11.97	22.75	74.44	681.0	9.24	0.772

The examination of this table shows that this turbine, of which the fall at the time of making these experiments, was about (2 metres) $6\frac{56}{100}$ feet, realized a net useful effect equal to 0.772 of the theoretical power expended by the motor.

XXIX.

General Summary of the Experiments on the Useful Effect of Turbines.

From the whole of the experiments contained in this memoir, and of those which had before been made relative—

To the Turbine of Moussay, where the height of the fall has been, during the experiments, about (7.50 m.) $24\frac{61}{100}$ feet, and where the wheel has been immersed under water about (0.974 m.) $3\frac{19}{100}$ feet.

To the Turbine of Müllbach, where the height of the fall has been, during the experiments, about (3.50 m.) $11\frac{48}{100}$ feet, and which has been immersed under water about (0.750 m.) $2\frac{46}{100}$ feet.

To the Turbine of Lepine, where the height of the fall is (2 m.) $6\frac{56}{100}$ feet.

*To the Turbine of Inval,** where the height of the available fall has been successively reduced from (1.174 m. to 0.293 m.) $3\frac{85}{100}$ feet to $\frac{96}{100}$ of a foot, whilst, on the contrary, the depth to which the wheel was immersed, has been augmented from (1.15 m. to 1.74 m.) $3\frac{77}{100}$ feet to $5\frac{71}{100}$ feet.

* See the Compte Rendus des Seances de l'Academie des Sciences, No. 9, 27th February, 1837.

Finally, from results obtained at the spinning factory at St. Blaise, in the Black Forest, where they used a fall of (108 m.) $354\frac{35}{100}$ feet! *with a turbine of* (0.55 m.) $1\frac{80}{100}$ *feet diameter, making* 2300 *turns in a minute! and transmitting a power of* 40 *horses!*

We are able to conclude:—

1. *That these wheels are equally suitable to the greatest, as to the smallest, falls.*
2. *That they transmit a net useful effect equal to* 0.70, *or* 0.78, *of the theoretical power expended by the motor.*
3. *That they are able to move at velocities extremely distant, more or less, from that which belongs to the maximum effect, without the useful effect differing notably from this maximum.*
4. *That they are able to do duty under water at depths from* (1 *to* 2m.) $3\frac{28}{100}$ *to* $6\frac{56}{100}$ *feet, without the ratio of the useful effect to the theoretical power of the motor, diminishing notably.*
5. *That as a consequence of the preceding property, they use all the time the whole available fall, since we place them below the level of the lowest waters.*
6. *That they are able to receive very variable quantities of water without the ratio of effect to power expended, diminishing notably.*

If we unite to these valuable mechanical properties, the advantage that they offer of occupying but little space, of being able, without any great expense, and without embarrassment, to be established in such part of the works as we wish, of moving generally at velocities much superior to those of other wheels, thus avoiding recourse to the transmission of complicated motions, *we conclude (without doubt with us) that these wheels ought to take rank amongst the best hydraulic motors.*

Experiments on the useful effect of Turbines in the United States. By Ellwood Morris, Civil Engineer.

The above series of experiments on turbines, made by Morin, corroborated by other experimenters, and finally sanctioned by the approbation of the Academy of France—after undergoing the scrutiny of a special committee of their body deputed for that purpose—are beyond the reach of cavil, and must carry a conviction of the value of these hydraulic motors home to the minds of all who are capable of appreciating subjects of this nature.

Nevertheless, when the writer, some time ago, formed the resolution to attempt the introduction of these valuable water-wheels into use in our country, and entered into a business arrangement with Merrick & Towne, the well known machinists of Philadelphia, for that purpose, they were met at the threshold of their enterprize by an unusual degree of scepticism, which, unfortunately, received here, as in France, a slender resting point from the abortive efforts to construct successful turbines, which were made by some not sufficiently acquainted with the principles of these motors, whose attention had

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In consequence, it seemed in some degree, incumbent on the writer, who had publicly declared the value of these motors, to demonstrate the apparent truism, that with properly constructed turbines, acting under a given quantity and fall of water, the economical results are the same in America as in France.

With this object in view, the writer has carefully tested the only two turbines made by Merrick & Towne, from his drawings, which have yet been put in action.

The first of these was set to work upon the 1st of January, 1843, at the Rockland Cotton Mills, upon the Brandywine stream, and has been running ever since with perfect success, and to the entire satisfaction of the proprietors.

It has continued to run, and drive the cotton mill at full speed, when the fall was reduced one-half by backwater, and when a large breast water-wheel, actuated by the same head race, was unable to turn for days together.

The experiments made upon this turbine, in the presence, and with the aid of the Messrs. Young, of Rockland, were communicated, by the writer, to the American Philosophical Society, on the 30th of May last, at the celebration of their hundredth anniversary, and will be found recorded in their published proceedings, whence the following is extracted:

"The experiments made in France, with the brake of M. Prony, have established, that the coefficient of effect of turbines, or the ratio of power actually realized, to that expended, *is, at an average, seventy per cent.* Mr. Morris has recently tested this result at the Rockland Mills, in Delaware, where the turbine is employed to drive a cotton mill: his experiments are collated in the table which closes this abstract.

"From these tabulated experiments it will appear that with lifts of sluice-gate, ranging from 5 to 7 inches, or from $\frac{5}{9}$ to $\frac{7}{9}$ of the full height of the turbine, and with velocities, at the inner circle, varying from about $\frac{3}{10}$ to near $\frac{5}{10}$ of the theoretical velocity, due to the working fall of water, this motor realized an useful effect, varying from 64 to 70 per cent. of the absolute power expended, or of that which is theoretically due to the expenditure of water, and the available fall at the time.

"The maximum effect seems to have been derived when the lift of the sluice-gate equalled 6 inches, or two-thirds, of the full height of the wheel; and when the turbine, at its inner circle, ran at a speed equivalent to 46 per cent. of the theoretical velocity of the water, issuing, under a head, equal to the working fall.

"An examination of the experiments from the 6th to the 14th inclusive, will show that the coefficients of effect within these limits, notwithstanding considerable variations in the relative velocities of the wheel, and its impelling water, averaged 67 per cent.; thus showing that this turbine, when run with a strong lift of sluice-gate, realized

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as high a coefficient of effect, as was assigned by Smeaton to overshot water-wheels.

"With regard to the following table, Mr. M. remarked that the quantity of water used, which fixes the theoretical power due to the expenditure and descent, was determined by applying to the openings of the directing sluices certain coefficients of discharge, deduced from those of Morin, on the turbine of Müllbach, by a comparison of the velocities and lifts of gate in the one, and the other case: the results, therefore, are merely proximative, but cannot be very distant from the truth.

"The total fall of water at the Rockland Mills is usually about 7 feet; but the turbine has continued to drive the machinery of the mill effectively when the difference of level was reduced by backwater to three feet three inches, and the wheel was entirely submerged to the depth of four feet. With an external diameter of $4\frac{2}{3}$ feet, and a vertical thickness of about 8 inches, it propels the same machinery which heretofore required two breast wheels, one of 14 feet bucket, and 10 feet diameter, the other of 8 feet bucket, and 16 feet diameter, and uses one-third less water than the latter of these alone.

"Mr. Morris next adverted to the durability of the turbine; he supposes it less liable to wear at the pivot than the common water-wheel; as the latter while running supports a heavy load of water, from which the turbine is relieved by the interior fixed disc, which carries the directing sluices. In the turbine at Rockland, the pivot is ingeniously lubricated with oil by a syphon wick, the oil passing through an opening in the centre of the vertical shaft; after five months' use, the wear of the pivot is not perceptible." *

* At the time these pages are passing through the press, this turbine has been running eleven months, and no indications of wear are yet displayed by the pivot. We may, therefore, conclude, that no apprehensions need be entertained concerning the wear of the pivots of such turbines as are lubricated in this manner.

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Experiments upon the Turbine at the Rockland Mills, near Wilmington, Del., made by Ellwood Morris, C. [cut off]
January 21st, 1843.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of the experiments.	Vertical lift of the annular sluice-gate in inches.	Aggregate area of the fixed disc open'gs exposed by the sluice-gate in sup. feet.	Proximate coefficients of discharge of the fixed disc openings.	Depression of the water surface in the head and tail races below a fixed level.		Working fall during the experiments.	Theoretical velocity of water due to the working fall in feet per second.	Proximate quantity of water discharged by the Turbine in cubic feet per minute.	Theoretical power in horses power of 33,000 lbs. lifted one foot high per minute.	Useful effect produced by the turbine as actually measured by the brake dynamometer of M. De Prony.			Ratio of the speed of the wheel at the inner circle, to the theoretical velocity of the water due the working fall.	fect, or ratio, of the power actually realized, to the theoretical power.
				In head race.	In tail race.					No. of turns of the wheel per minute.	Load of brake at the end of a radius of 11 feet.	Horses' power developed of 33,000 lbs. lifted 1 foot high per min.		
1	1	0.344	.930	3.083	9,937	6.854	20.9	401	5.2	38	14	1.1	.317	.211
2	2	0.687	.923	3.083	9.625	6.542	20.5	779	9.6	58	28	3.4	.500	.354
3	3	1.031	.918	3.125	9.479	6.354	20.2	1146	13.8	72	42	6.3	.621	.456
4	4	1.375	.830	3.188	9.271	6.083	19.8	1855	15.2	74	56	8.6	.652	.566
5	4	1.375								59	70	8.6		
6	5	1.719	.724	3.125	9.187	6.062	19.7	1471	17	57	98	11.7	.505	.688
7	5	1.719	.742	3.125	9.187	6.062	19.7	1507	17.3	67	74	11.8	.593	.682
8	6	2.062	.720	3.229	9.208	5 979	19.6	1745	19.8	64	98	13.1	.565	.662
9	6	2.062	.720	3.229	9.208	5.979	19.6	1745	19.8	59	108	13.3	.525	.672
10	6	2.062	.700	3.188	9.125	5.937	19.5	1688	19	46	136	13.1	.411	.690
11	6	2.062	.700	3.188	9,125	5.937	19.5	1688	19	52	122	13.3	.465	.700
12	7	2.406	.700	3.125	9.042	5.917	19.4	1960	22	49½	136	14.1	.445	.641
13	7	2.406	.700	3.104	8.958	5.854	19.3	1950	21.6	56½	122	14.4	.510	.667
14	7	2.406	.700	3.146	8.958	5.812	19.3	1950	21.1	60	115	14.4	.542	.688

Since these experiments were communicated to the Philosophical Society, the second turbine has been put in operation at the powder works of the Messrs. Dupont, in Delaware.

The writer availed himself here of the liberality and aid of Alfred Dupont, Esq., (whose extensive experience in the use of water power is well known,) to make a series of trials with this motor, in which the amount of water used by the turbine, inclusive of a small leakage from the fore-bay, was measured in two ways:—

1. By causing it to pass through the rectangular aperture of a common head-gate, under different heads.

2. By causing it to flow with a clear fall, over the edge of a waste-board notched 6 feet wide, and 9 inches deep, and placed in the tail-race, where it was 9 feet wide between the side walls.

The coefficients of discharge to be applied to the theoretical expenditure from the openings of rectangular gates and waste-boards, in order to determine the actual quantity of water passing in a given time, have been so fully settled by numerous experiments, that scarcely any more satisfactory mode of measurement could be devised.

In calculating the results of the following table, the formula used for the head-gate measurements is

$$^* Q = 0.625 \sqrt{2gH} \times A;$$

where Q = actual quantity of water passing per second in cubic feet.
$2g = 64\frac{1}{3}$ feet.
H = the head in feet under which the water issued through the opening exposed.
A = area of gate drawn in superficial feet.

This formula, to facilitate the calculations, is usually transformed into

$$Q = 5 \sqrt{H} \times A,$$

in which shape we have applied it.

In the four experiments, where the waste-board was employed as a meter of the quantity of water used, it so happened that the depth of the sill beneath the surface of the still water above, was almost exactly the same as the depth of the notch, *or 9 inches.*

Now, for this depth the coefficient of discharge has been shown by Poncelet, and Lesbros, from actual experiment, to be 0.385, and hence the formula for the expenditure by the waste-board would be

$$\dagger\ Q = 0.385\, LH \sqrt{2gH},$$

where Q = quantity of water discharged per second.
L = length of opening of waste-board.
H = depth of the sill, or edge, below the level of still water = 0.75 feet in this case.
$2g = 64\frac{1}{3}$ feet.

computed by this formula, the flow over the waste-board was 12 cubic feet per second.

* See Morin's "Aide Mémoire de Mechanique Pratique," edition of 1843, ps. 6 and 23.
† See Morin's "Aide Mémoire, p. 37.

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between the experiments recorded in the following table, and those of Morin on the turbine of Müllbach, the writer has adopted, for the waste-board, the same formula that Morin used, viz.,

$$Q = 0.405\,LH\sqrt{2gH};$$

this formula gives a greater expenditure, and, of course, a lower coefficient of effect for the turbine than the former.

It will be borne in mind that in the following table the quantities of water used, actually include whatever leakage existed in the forebay, but as this did not seem to be very considerable, and as it was the wish of the writer not to undervalue the amount of water expended by this turbine, he did not think it worth while to measure and deduct the leakage referred to.

The turbine experimented upon, in this instance, has an exterior diameter of 4 feet 5 inches, its height is 6 inches, and throughout the experiments the lift of the sluice-gate was uniformly $4\frac{1}{2}$ inches, or three-fourths of the full height.

With the view of ascertaining the statical force exerted by Dupont's turbine with $4\frac{1}{2}$ inches gate drawn, weights were added in the scale, and the brake was screwed up, on two occasions, until the wheel stopped. It was then found that the standing power of this turbine, or the weight which it equilibrated, was 198 pounds at the end of a radius of 6 feet, when the fall was $4\frac{2}{10}$ feet, and 190 pounds under a fall of $4\frac{1}{10}$ feet.

These experiments offered also, to the eye, an excellent demonstration of the truth, that, when turbines run at their proper speed, the water drops from them *without velocity;* for when the wheel was stopped by the brake, the water rushing from the buckets with a velocity due to the fall, reacted violently from the walls of the tail-race, and produced a great commotion in the tail-water. But the moment the screws of the brake were relaxed, and the wheel had gained its proper speed, the tail-water became perfectly calm, and flowed away in a smooth, unbroken sheet; thus clearly showing that the water quitted the wheel without velocity, for otherwise it would have reacted from the walls, and disturbed the tail-water as before.

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Experiments made Oct. 3rd and 4th, 1843, *by Alfred Dupont, Esq., and Ellwood Morris, C. upon the Turbine at the Powder Works, on the Brandywine, near Wilmington, Delaware.*

1	2	3	4	5	6	7	8	9	10	11	12	13	1[illegible]
									Useful effect produced by the Turbine, as actually measured by the brake dynamometer of M. de Prony.				
Number of the experiments.	Vertical lift of the head-gate drawn to admit water to the Turbine.	Width of the head-gate drawn.	Opening of the head-gate drawn.	Head under which the water issued through the openings of col. 4.	Quantity of water used per second, or that which passed to the turbine thro' the openings of head-gate drawn in column 4.	Working fall during the experiments.	Theoretical velocity of water due to the working fall per second.	Theoretical Power in horses-power of 33,000 pounds lifted one foot high per minute.	Revolutions of the wheel per minute.	Load of the brake at the end of a radius of six feet.	Horses power developed of 33,000 lbs. lifted one foot high per minute.	Ratio of the speed of the wheel at the inner circle, to the theoretical velocity of the water due to the working fall.	power actually realized, to the theoretical power of the water.
	Inches.	Inches.	Sup. ft.	Feet.	Cub. feet.	Feet.	Feet.	H. pr.	Revolu.	Pounds.	Hrs. pr.	Ratio.	Co
1	Water measur'd by waste-board.				12.63	4.1	16.2	5.6	25.	119.	3.4	.254	.5
2	6.	30.75	1.28	2.4	9.92	2.9	13.6	3.3	28.	63.	2.	.332	.6
3	18.	"	3.84	0.46	13.02	4.7	17.3	7.	36.	119.	5.	.336	.7
4	Water measur'd by waste-board.				12.63	4.1	16.2	5.6	39.	91.	4.	.389	.6
5	31.	30.75	6.62	0.208	15.09	4.9	17.7	8.4	49.	112.	6.3	.447	.7
6	18.	"	3.84	0.5	13.57	4.6	17.2	7.1	50.	91.	5.2	.470	.7
7	12.	"	2.56	1.	12.80	4.2	16.4	6.1	48.	80.	4 4	.473	.7
8	Water measur'd by waste-board.				12.63	4.1	16.2	3.6	50.	73.	3.4	.498	.7
9	12	30.75	2.56	1.1	13.44	4.2	16.4	6.4	52.	70.	4.2	.512	.6
10	12	"	2.56	1.1	13.44	4.	16.	6.1	56.	63.	4.	.565	.6
11	Water measur'd by waste-board				12.63	4.1	16.2	5.6	57.	63.	4.1	.569	.6
12	16	30.75	1.28	2.6	10.24	2.7	13.1	3.1	50.	85.	2.	.614	.6
13	12	"	2.56	1.1	13.44	4.	16.	6.1	62.	49.	3.5	.625	.5
14	12	"	2.56	1.1	13.44	4.	16.	6.1	65.	42.	3.1	.656	.5
15	12	"	2.56	1.1	13.44	4.	16.	6.1	70.	85.	2.8	.770	.4

Observations on the above Table.—In the 1st, 4th, 8th, and 11th experiments, the turbine was entirely submerged to a depth of 28 ins., and in all the rest its top ran 18 inches under water.

The experiments from 1 to 3 inclusive, show that even with velocities, at the inner circle, ranging so low as from 25 to 33 per cent. of

The experiments from 4 to 9 inclusive, show that when the turbine ran at a speed of from 40 to 50 per cent. of the theoretical velocity of the water (within which limits this wheel will always move,) it realized, at an average, about 71 per cent. of the theoretical power of the water; and the 5th experiment, which indicates the maximum effect, shows that when running with a speed of 45 per cent. of that of the issuing water, *its coefficient of effect reached seventy-five per cent.*

The experiments from 10 to 15 inclusive, show that with the high relative velocities of 50 to 70 per cent. of that of the issuing water, this turbine still retained an average useful effect of near 60 per cent.

The 12th experiment shows that even with a fall of but $2\frac{6}{10}$ feet, and though the wheel ran at too great a velocity, it still realized 64 per cent.

The above experiments, made with falls of water ranging from $2\frac{6}{10}$ up to $4\frac{9}{10}$ feet, and under a back-water equal to a third, or even a half, of the whole fall, corroborate those of Morin and others, upon these motors, and they prove, that whilst turbines possess a most singular power of adaptation to very different velocities without much loss of power, if their speed at the inner circle be confined within the limits of 40 to 50 per cent. of that due by theory to the issuing water, *we may safely calculate upon a useful effect of full seventy per cent.*

Before these pages issue from the press, there will be in operation *seven turbines*, constructed by Merrick & Towne, from the writer's drawings, to wit:—

One of 4 ft. 8 ins. diameter, driving a cotton mill at Rockland, on the Brandywine, in Delaware, with 6 ft. working fall.

One of 4 ft. 5 ins. diameter, driving a powder mill at Duponts, near Wilmington, Delaware, with 4 ft. working fall.

One of 4 ft. 8 ins. diameter, driving a woolen mill on the Crosswicks creek, New Jersey, with 7 ft. working fall.

One of 7 feet diameter, driving a heavy saw and plaster mill, on Millstone river, New Jersey, with 3 ft. working fall.

One of 6 ft. 6 ins. diameter, driving a woolen mill at Rokeby, on the Brandywine, Delaware, with 5 ft. working fall.

One of 3 ft. 2 ins. diameter, driving a grist mill on the Brandywine, near Coatesville, Pennsylvania, with 17 ft. working fall.

One of 6 ft. 6 ins. diameter, driving a large cotton mill at Phœnixville, Pennsylvania, with 8½ ft. working fall.

These turbines varying in power from 4 to 30 horses, applied to different uses, running under various falls of water, and all of them placed so as to be more or less submerged by back-water, will demonstrate their utility, to practical men, in a manner which cannot be mistaken.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Description of a Wrought-Iron Beacon erected at the harbor of Black Rock, in Long Island Sound, in the summer of 1843. By W. H. Swift, Capt. Corps Topl. Engs.

We are indebted to the officer who erected this work, for the following description, which we have prefaced with a brief history, derived from authentic sources, of other structures erected in the same place, all of which have been, sooner or later, overthrown.

The vast magnitude and growing importance of the light-house establishment, and the large sum annually appropriated for repairs in this department of the general government, may render this brief history interesting.

The harbor of Black Rock lies about 18 miles westward of New Haven; it is accessible at extreme low water for vessels drawing 10 feet, and at high water it may be entered by vessels drawing from 16 to 18 feet. As a harbor of refuge it is more resorted to, perhaps, than any other in the sound, the depth of water being sufficient in all cases, for that class of vessels which are usually employed in the navigation of this great thoroughfare.

In 1829 a beacon of stone was built at this place under the orders of the Treasury Department, at a cost of about 6000 dollars. This beacon was entirely destroyed by a gale of wind in less than one month after it was erected. In the year 1835 it was rebuilt at an expense of nearly 9000 dollars: in the spring of 1836 it was injured by a gale of wind, so seriously that, in all probability, it would have been entirely demolished by the recurrence of the first heavy gale. It was then repaired with a guarantee from the contractor, that he would maintain the beacon in its position for a period of five years: this was effected at a cost to the United States of 6500 dollars. One year after the expiration of this guarantee, (in 1842) the beacon was again so much injured by a gale of wind, that the whole structure must have fallen, had not the long stones of which the upper part of the beacon was constructed, been held together in place by the wooden spar, or mast, which was used for supporting the cask; the stones were laid around this spar, and it served to prevent them from separating from each other. Thus, it will be seen, that within a period of 12 years, three stone beacons have been destroyed at this place, and that the cost to the United States has been upwards of 21,000 dollars.

In March, 1843, an appropriation of 10,000 dollars having been made by Congress, for rebuilding the Black Rock Beacon, the Secretary of the Treasury applied to the Secretary of War to allow this beacon to be constructed under the direction of the Chief Topographical Engineer, and by the orders of Colonel J. J. Abert, the work was entrusted to the superintendence of Captain W. H. Swift.

Description of the work by Capt. Swift.

The beacon stands one mile and a half south of the entrance to the

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harbor, and is exposed to all winds from E.N.E.; around by the South to W.S.W.; from the East it is entirely open to the rake of the sea for a distance of sixty miles.

When the first beacon was built in 1829, a large quantity of pebble stone was carried in vessels to the proposed site, and there thrown into the water around a single rock called the "Old Huncher," and upon which there had been an iron spindle in former years; this rock was conical in shape, about 4 feet in diameter at top, and bare at very low water. Upon this loose stone, thus deposited, the superstructure was reared, and when the beacon was overthrown, the materials of which it was composed, were, of course, added to the rubble stone bed, and they, in turn, became the foundation for the beacon of 1835.

In the examination which I made of the site in June, preparatory to making the final plan for the iron work, I ascertained that the stone below low water, had, apparently, remained unmoved for a long time, and I subsequently found, by inquiring of Capt. Wilson, the contractor, who had repaired the beacon in 1836, and who had maintained it in repair for five years, that such was the fact; while, as he stated, and it was evidently true, the stones between low and high water were thrown about by the force of the sea in every gale. This was fully exemplified too by the appearance which the injured part of the old beacon presented; the base, or that part below low water was entirely undisturbed, the breach being between high and low water marks; all the stone below low water remaining, as stated by Capt. Wilson, as they were when the beacon was repaired in 1835.

There being no stone of sufficient size at the old beacon into which the iron shafts of the new structure could be secured, I found it necessary to procure elsewhere such as were suitable for the purpose, and to transport them to the site, and imbed them below the line of low water, in order that the sea might not disturb them after they should be laid.

Description of the stone foundation.

The beacon, according to the general plan which I had made, and submitted to Col. Abert on the 30th of April last, was to be elevated 36 feet, and for this height I decided to give the iron shafts a spread, or base, of 16 feet, with an inclination towards the centre of about 1 to 6. In order that there should be sufficient strength in the stone to resist any tendency there might be to fracture at the holes which were to receive the feet of the shafts, I adopted the dimension of 20 feet as a suitable diameter for the stone bed designed for the shafts to be secured to; this dimension gave a distance of about 2½ feet from the centre of the shaft holes to the edge of the stone at top, while at the bottom of the stone, where the strain is less, it would be 2 feet. The bed then is composed of 6 pieces of hammered granite, 2½ feet thick: the middle stone is round, and is 8 feet in diameter, the five outer stones are 6 feet wide by about 12 feet in length, each stone weighing nearly 12 tons; the stone are cramped and doweled together with 1½ inch round copper, two at each joint, the cramps 2 feet long, and the dowells 10 and 12 inches long.

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88 ft. from north to south is exposed,) for the reception of the stone bed is a few feet N.W. from the old beacon, it was 26 feet in diameter, and 3 ft. below *ordinary* low water. When the excavation was completed, a layer of concrete, composed of 5 parts of hydraulic lime, to 8 parts of sand, was spread over the bottom of the pit by means of a trough of wood for the foundation stone to rest upon. After the stones were laid, which was effected by means of a heavy pair of shears, and a "Lewis," the unoccupied space in the pit around the outside of the stone bed, was filled with concrete and rubble stone flush with the top of the foundation stone. As it was only at, or near, low water that this part of the work could be carried on, that is to say ordinarily, about three hours per day in good weather, considerable time was necessarily consumed in getting in the foundation; from the day the shears were erected to the day the stone work was completed, was just five weeks.

Description of the Iron work.

The figure of the beacon is that of a truncated pyramid; it is formed of six wrought-iron shafts, five of them 36 ft. 7 ins. in length, standing in the periphery of a circle of 16 ft. diameter, and one 36 ft. long at the centre, the outer shafts incline towards the middle in such proportion, as to fall at the top within the circumference of a circle of 3 ft. diameter; each of these shafts is composed of two pieces of equal length, the diameter at the foot of the lower piece is 5¼ ins., and at the top 4 inches; the diameter of the upper piece is 4 ins. at the foot, and 3 ins. at the top, they are united by a cast-iron socket of 3 ft. in length, 2½ ins. thick at the joint of the shafts, which is at the middle of the socket, 2 ins. thick at the top and bottom, and 1 inch thick elsewhere; the top of the lower shaft is made concave, and the bottom of the upper shaft convex, fitting one into the other. At the distance of one foot from the joint of the shafts, a steel key 2 inches deep by ¾ of an inch wide, passes through the socket and each shaft to secure them together; the sockets inside, and 18 ins. of the ends of the shafts are turned and accurately fitted to each other. At a distance of 2½ feet from the foot of the lower shafts, are 4 shoulders one foot long, and projecting, at the lower extremity, one inch from the shaft to form points of support for the same at the surface of the foundation stone. Above and below the joints of the shafts, and at distances of 9 ft. and 18 ft. respectively above the top of the stone, are two sets of braces extending from the middle shaft to each outer shaft, and from one outer shaft to another, making ten in each set; the braces are of wrought-iron 2½ ins. square, the extremities are secured by 1¼ inch screw bolts to cast-iron collars, these collars are strengthened by two wrought-iron bands, and are firmly attached to the shafts by steel keys; the space between the collar and shaft, and between the keys is filled with zinc; the braces are secured to the collars in such a manner that they serve for ties in case of any unforseen strain acting

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from the *interior* of the beacon, such as might possibly be occasioned by ice, or any other floating body.

The top of the shafts are provided with shoulders to support a cast-iron cap, composed of five arms, each 3 ft. in length, and 4 ins. in width, strengthened by a rib, or flanch, of 3½ ins. in depth; the shafts pass through this cap 18 inches from the centre of it, and are there keyed in place; a wrought-iron band 3 ins. wide, and ½ inch thick, is shrunk upon the extremity of these arms to add to its strength; from the ends of the arms of the cap, 3 ft. from the centre, braces of 2 ins. round iron descend 4½ ft. to the main shafts, and are there secured by screw bolts passing through their extremities, and through the shafts also. At this junction of the braces with the shafts, a wrought-iron band, similar to that which encircles the cast-iron cap, is fitted and bolted at a distance of 4½ ft.; again below this second band is a third band similar to the two others, and similarly secured by screw bolts through the shafts; finally, there are 10 panels, or gratings, 4½ feet long, corresponding in shape and dimension with the wrought-iron bands between the shafts, and the wrought-iron bands; these gratings are made of boiler iron $\frac{3}{16}$th of an inch thick, with eight horizontal and 3 vertical slats, or bars, 3 ins. wide, riveted together: the horizontal slats are 3 ins. apart, but at the distance of 500 yards, the top of the beacon presents the appearance of an opaque body 9½ ft. long by 6 ft. wide at the top and bottom, and 4½ ft. wide midway of the same.

The feet of the iron shafts penetrate the stone foundation 2½ ft., and are secured in their places by heavy iron wedges fitted to the unoccupied spaces between the sides of the holes in the stone and the shafts; the holes being inclined, and the braces between the shafts being immovable. It is evident that the feet cannot be withdrawn from their places without rupture. Now, the braces are of 2½ inch square iron, and the thickness of the stone outside of the hole is 2½ feet, and this would seem to present sufficient strength to resist a shock from any ordinary cause.

In addition to the concrete around the outside of the stone, and the cramps and dowells to secure the same together, there are five iron ties of 1½ ins. diameter, extending from a collar of two inch wrought iron, which surrounds the middle shaft, to each of the outer shafts to which they are firmly and securely attached by means of heavy iron stirrups; the ends of the ties are furnished with screws and nuts, and by this means can be kept in a constant state of tension. This arrangement was resorted to as an additional means of preventing any tendency there might be in the outer foundation stones to separate themselves from the middle stone.

The beacon, as finished, stands 34 ft. above low water, and 3 ft. higher than the old beacon; the cage, or grating, is *painted black*, and the shafts vermilion red.

A model of the work upon a scale of one inch to a foot will be deposited in the Bureau: this, with the accompanying plan in detail, will convey all the information in reference to the construction which may be required.

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The iron work was executed in Boston by Messrs. Cyrus Alger & Co., under the immediate superintendence of Mr. Lester; the entire weight is upwards of 19,000 lbs. The foundation was prepared, and the beacon erected in place by Mr. Benjamin Pomeroy, of Stonington, Ct., under a contract made with him for that purpose. The entire cost of the iron work and foundation was about 4600 dollars, and the time consumed in the construction was three months.

I had it in contemplation at one time to coat the iron work with zinc, by means of electro-galvanism, but I found that too much time would be required for preparing the necessary tanks and apparatus. I venture to hope, however, that another occasion may present itself, and that in the more important structure of the "screw pile light," which, I trust, I shall one day see executed upon our own shores, that the galvanizing process may be successfully applied.

In conclusion I beg to call attention to one or two of the more important advantages which this application of one of the principles of Mitchell's Screw-pile, to the construction of light-houses and beacons, presents.

In a very exposed situation, a light, or a beacon, if built of masonry, can only stand when the best description of work is introduced; this, of course, involves great expense, and much time. The mode of construction for such situations must, in principle, be similar to that adopted for the Eddystone and Bell Rock lights, and this, as all know who understand the subject, would, in the case of our own coast, present *an insuperable objection;* for example, the Bell Rock Light, on the coast of Scotland, cost £360,000, or 1,800,000 dollars, and four years were required to build it, this too in a situation where the rock upon which it is placed is bare at low water. The Eddystone was neither so costly, nor did it require so much time to complete it, still $ would, with us, justly be considered out of the question for a single light.* There are many places upon our coast at which the screw pile light could be erected at a very moderate cost, far less, indeed, than that of a light ship; notwithstanding this there are at this time not less than   floating lights in Pamlico Sound, on the coast of North Carolina. The Middle Ground, in Long Island Sound, upon which there are only 3 feet at low water, and at which a light boat is now maintained, is, of all others, the most suitable point to make the first experiment upon with this description of light.

In reference to the durability of wrought-iron exposed to the action of sea water, I have not a great deal of information to impart, still I have some which bears upon this question. Upon many of the reefs in Long Island Sound, and more particularly in Fisher's Island Sound, it has been the practice for many years to erect wrought-iron spindles of about 4 inches diameter, and from 15 to 25 feet in height; such spindles last from 15 to 20 years, unless carried away by ice. The contractor who placed several of these spindles, informed me that

* The Car Rock Beacon, on the coast of Scotland, cost 25,000 dollars; six years were required for the construction; it was intended to build it entirely of stone, but when half finished the upper part was constructed of cast-iron. The cast-iron beacon on York Ledge Maine, is an exact copy of the Car Rock Beacon: it cost 10,000 dollars.

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and low water, and in this particular case, the size of the spindle is reduced from 4 to 2 inches in diameter. If, however, the zincing process, or if a precipitate of copper, be resorted to, there is every reason for believing that the iron thus protected would last twice, or three times, 20 years. In short, economy in cost and in time, and the application of the principle of the screw pile in situations where masonry could not be resorted to without inordinate expense, would seem to be advantages in themselves sufficient to justify extensive experiments in a branch of the public service of such importance as that of our light-house system.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

(Continued from page 306.)

Lecture xvi.—Working Expenses of Railways—*(Continued.)*

The result of the examination into the expense of passenger traffic had been investigated in the last two lectures, and a general average cost had been deduced, varying from two-thirds of a penny to one penny per mile per passenger, including the Government duty, the fraction varying, of course, with the number of passengers in the train. It would not be necessary to go as minutely into the items of corresponding expense of merchandize and mineral traffic, nor would this last lecture but one of the course allow sufficient time to do so. Mr. Vignoles said he should endeavor to compress what he had to explain further about railway expenses into this evening's address, and, in the concluding lecture, he would take a general review of the whole of his course on railway matters. The cost of carrying coals, at very moderate velocities, on the great colliery railways, is about one penny per ton per mile, which may be divided into the following heads, viz:—

Expense of Transport of Coal.

	Dec. of a penny.
Locomotive power, - - - -	.38
Wagons, - - - - -	.19
Conducting traffic, - - - -	.08
Maintenance of railway, - -	.21
General expenses, including local taxes,	.14
Per ton of coal per mile, -	1.00

The proportion of the weight of the coal to the gross load carried being as 3 to 5. The expense of carrying goods on the Liverpool and Manchester Railway, taken on the average of seven years' traffic, appears to be about 2½d. per ton per mile, divided as follows:—

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Expense of Transport of Merchandize.

	Dec. of a penny.
Locomotive power, - - -	.57
Wagons, - - - - -	.23
Conducting traffic, - - -	1.08
Maintenance of railway, - -	.31
General expenses, including local taxes,	.35
Per ton of goods per mile, -	2.54

But in this sum is included a considerable item, which does not properly belong to the railway itself, viz., the cost of collecting and delivering the goods all over the towns at the two termini, by carts and wagons, and full ½d. per ton may be taken off for this item—making the total expense 2d. per ton per mile—the proportion of useful weight, of weight of merchandize carried, to the gross weight, including the wagons, being as 1 to 2. We have now the results of many years' working expenses of railways for passengers, as we have investigated in the two last lectures, and, as above, for coal and merchandize, which may be tabulated thus:—

Expense of Railway Transport per mile.

Passengers, at high velocities, - - -	1d. each.
Coal, at very moderate speed, - - -	1d. per ton.
Merchandize, at fifteen miles an hour, - -	2d. "

Reducing the expenses of passenger traffic to a tonnage—taking the weight of twelve passengers and their luggage as being, on the average, equivalent to a ton—we obtain 1s. per ton per mile, which is twelve times the expense of carrying coal, and six times that of conveying goods. A portion of this difference, but not all, is due to the velocity, for, though it would seem that this doubles the cost of goods, as compared with coals, it is not so in fact, as a large proportion of expense is incurred in the handling and office work necessary for merchandize traffic, to which coal is not liable. Comparing the proportion, between the useful, or paying, load, and the gross weight moved, including the vehicles, we have, coal 3 to 5, merchandize 1 to 2, and, as explained in the preceding lectures, passengers 1 to 6, and often more. The consideration of the comparative view in this light led Mr. Vignoles to observe, that, notwithstanding the apparent difference, there is a great analogy between the proportion, as regards goods and passengers, for, if the passenger trains could be fully loaded, the proportion between the profitable, and the gross, load, would be nearly the same, both for passengers and merchandize, the result being almost similar, as regards the actual weight to be transported, and the preparation to be made for moving the mass—at the same time, it was an additional and collateral proof that the figures laid down in the above general terms, by the Professor, might be depended upon. On colliery and mineral railways the traffic is arranged so as to carry the *maximum* profitable load on a *minimum* weight of vehicle; supposing coal and merchandize were really conveyed on equal terms in every thing except speed, the difference in velocity would appear

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difference of expense due to velocity, may, perhaps, be stated at from .50 to .60 of a penny per ton per mile as a *maximum;* the remainder of the difference is chargeable to the mode of conducting the traffic; and, in reference to the passenger trains, it should be borne in mind, that it is the necessity of meeting the fluctuation of passenger traffic, and, in order that the public may be accommodated, that, taking weight for weight, it costs railway companies six times as much to convey passengers as to transport goods. On the other hand, ten years' experience of the working of the Liverpool and Manchester Railway produces the result that their profit upon the conveyance of a single passenger averages the same as the profit on the carriage of a ton of merchandize. But why? On that line, there being a great competition with the river and canal navigation, the rate of charges for goods has been brought down to the lowest terms, for the utmost possible extent of accommodation of warehousing, delivery, &c.; but there being a practical monopoly in the conveyance of passengers, the fares are not quite to a *maximum*, but still very high. Mr. Vignoles observed, in applying these facts, that it had been one of the objects of these lectures to show, and he wished to enforce it on the minds of the class, as a useful and easily attainable result, that, by sending trains more frequently, with fewer carriages, and by constructing those carriages to a better proportion between the paying and the unprofitable load, the increased accommodation would bring increased traffic; for, considering that the expense of transport is but little affected by the number of passengers, by such increase the expenses, as computed per passenger per mile, might be fairly calculated as susceptible of being reduced from 1d. to ½d.; supposing every other condition to be as at present: another advantageous consequence would be that of keeping the engines above their work. Such an arrangement of trains bore greatly upon the important question of what amount of extra expenditure on railways could be fully justified by prospectively consequent beneficial results; but the Professor said he would not again enter into the question of gradients. The necessity of perfect gradients assumed *maximum* loads as generally occurring, whereas exactly the opposite was the case in practice, especially with passenger trains, and on lines in districts not adjacent to the metropolis, or our largest commercial and manufacturing towns; indeed, it is remarkable how nearly alike in all railways, whose gradients differed greatly, were the working expenses per train per mile. On the North Union Railway, for example, where five miles out of twenty-two are at an inclination of fifty-three feet per mile, the mileage expenses of working trains is quite as small as upon railways of which the gradients are nearly horizontal; and it was found that up to six or eight carriages, or from that number even up to ten vehicles per train, no very material mileage difference of working expenses results on lines with what are called comparatively favorable, or unfavorable, gradients. Mr. Vignoles then referred to a former lecture, wherein he had considered how far beyond 10,000*l.* per mile, as the total cost of any given line of railway, it was justifiable to incur increased ex-

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pense in the formation, to obtain more perfect gradients, or to make the railway at all. He observed that the late Irish Railway Commissioners had distinctly shown by a different process of reasoning, and on different data, that any excess above this sum could seldom be advisable in agricultural countries, or where the traffic was inconsiderable, and the Professor strongly insisted that it was more expedient to encounter inclinations of fifty, sixty, or even eighty, feet per mile, with lighter trains, or heavier engines, and at a somewhat greater cost of working per mile, than to incur the expense of vast excavations and embankments, and costly works of art, to obtain better gradients. He particularly referred to his own practice in this respect, and to his report to the above commissioners on the laying out of the railways in Ireland, and observed that the French engineers had fallen into a great mistake in proposing such expensive sections for the French lines. On the Liverpool and Manchester Railway, and, indeed, on several other lines, the expense of locomotive power was only about one-fourth of the whole cost of transport; but, supposing it to be as much as one-third, it would be found that not a third part of this third, or not more than one-ninth part of the whole working expense, was effected by the gradients, and nearly all other expenses, beyond increased fuel and repairs, on account of steep inclinations, were common to all lines, and depended upon management rather than the gradients. If the number of miles run by engines with trains, and the total annual cost of working various railways, were taken, and also the corresponding amount of gross receipts and net returns per train per mile, and a comparison made with the interest of the capital expended, it would be found that on very few lines, indeed, had the vast expense of obtaining good gradients been justified. Mr. Vignoles observed that, having determined the cost of conveying goods and passengers, as before explained, and having ascertained the probable amount of traffic, it would be found that the public could seldom afford to pay higher charges than such as, in addition to the cost to the company, would leave them a profit per passenger per mile of 1d.; per ton of goods per mile of 1d.; per ton of coals per mile of ½d. On the continent the people could not give half the above, and so in Scotland and in Ireland; any increase driving the traffic into other channels, as in the case of the Paisley and Greenock Railway, or, perhaps, stopping it altogether. On the great traveling lines monopoly entirely kept up higher prices, but intercourse was thereby greatly impeded, and the public suffered, and the traffic returns published, showed that the limits of receipts had been attained on many of them. On the Dublin and Kingstown Railway the average expense of conveying passengers was only ½d. per mile, and the profit to the company a trifle above that figure—say, about five-eighths of a penny per passenger per mile; this low fare produced a steady and regular increase of intercourse. The profit to the great English railway companies was about 2d. per passenger per mile, which was, perhaps, often not more than what was requisite to pay for the great, and, as the Professor argued, the useless, increased expense of these principal lines, but the traveling public paid dearly for

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future railways might be dissected, and a judgment formed on how far it was advisable to have spent 250,000*l.* per mile on the Greenwich and Blackwall Railways, and an average of 50,000*l.* per mile for many lines whose prospects could never have justified it, particularly if *à priori* investigations, such as those here gone into, had been instituted.

To be Continued.

Franklin Institute.

Address of John Wiegand, Esq., *Chairman of the Committee on Exhibitions, preceding the reading of the Report of the Committee.*

Ladies and Gentlemen,—In conformity with our arrangements, we meet you this afternoon for the purpose of presenting our report on the Exhibition of American Manufactures, which is now before you, and of distributing the Premiums, and other honorary distinctions which we have had the pleasure to award. It is with no ordinary gratification that we perform this duty. Before proceeding to discharge it, we feel that our warm congratulations should be exchanged upon the triumphs of American industry, which are spread out in such rich variety and excellence in these spacious halls. Compared with the first exhibition of the kind held by the Institute, in the year 1824, how great have been the improvements, and how wonderful the changes we witness. We remember how limited in variety, and how imperfect in finish, were the specimens then exhibited.

It is but a few, a very few, years since, that the hope was, in any degree, entertained that we might be able, as a nation, to supply our own domestic wants.

A few short years, and we have even more than realized our most sanguine desires: we now stand forth competitors with the great manufacturing nations of the world. All this, too, has been accomplished in a period of time so short, when compared with the rise and progress of manufactures in Europe, that we can scarcely believe the evidence of our senses. It seems more the work of magic, than the result of our own skill and enterprize. All this, too, has been attained in the teeth of old and almost inveterate prejudices; and it is mainly these, which, at this hour, secures employment for the workshops of Europe. Thanks to the skill of our artisans, thanks to an intelligent community, these prejudices are being dissipated; and by stimulants such as these exhibitions afford, and by the dissemination of sound practical science, we may yet see our own manufactures universally preferred: and without the slightest purpose to pay a flattering compliment, may we not add, that, with our fair countrywomen rests much

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of the patronage which the arts require? And shall they not receive it?

We are not of the number of those who hold in horror a manufacturing population. We do not believe that such a class will be ever overworked, or starved, in this country. It is too capacious for such results. When we contemplate the extent of territory, the variety of soil and climate, and the difference in habits and pursuits, which these induce, we will, undoubtedly, come to the conclusion, that here all is presented which is calculated to lead to that diversity of occupation which is the true basis of individual and national prosperity.

Manufacturing establishments and towns we will, undoubtedly, have: we have them even now, and they are distinguished for their order, intelligence and morality, no less than for their industry.

But our manufacturing establishments will be located just where they can be conducted most advantageously for obtaining supplies, and securing a steady and profitable market—they will keep pace with population and wants. The extent of our country precludes the idea of any one section becoming the entire manufacturers for the other sections of the country; particularly of such articles as are indispensable to the wants and comforts of society. We already see such establishments springing up in the south and west; and we expect to see, in every State possessing the proper requisites, a due proportion of manufacturing establishments.

Our citizens understand their interests too well to send the produce of their farms, by long and expensive routes, to a market, and by the same expensive routes to obtain all their supplies of manufactured goods. They will have in their midst the artisan who can manufacture for them, and who will, at the same time, become a steady and profitable customer for agricultural products.

While we entertain these views, we freely admit that there are locations, which, from their peculiar facilities for obtaining all the material for manufacturing, and for distributing goods, must ever possess decided advantages for manufacturing purposes. Such a position is enjoyed by Philadelphia, and it may not be out of place here to remind the citizens of our own loved city, that if Philadelphia is to live and prosper, it must be mainly by the production of her own workshops. The field is large, and the harvest inviting and rich. If we fail to reap it, it will be because we are too blind, or indolent, or what may be equally as fatal, too cautious and hesitating in our movements. "There is a tide in the affairs of" cities, as well as of "men, which, when taken at the flood, leads on to fortune."

It is not our purpose to notice the objections urged against a manufacturing population, drawn from their condition in Europe. All that we ask is to let a due proportion of the generation, which are now enjoying the advantages of our public school system, become our mechanics and artisans, and all fears on this subject will be forgotten; and so long as an useful education is provided for every child in the State, such evils cannot long exist. It is wrong, it is unjust, to suppose that intelligent mechanics and artisans are less qualified

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for self-government than other classes of society. Intelligent industry dangerous? Why, it is a nation's best security.

This is not the time, nor is it any part of the object of the Franklin Institute, to discuss questions of political economy. The Institute, however, is founded upon the presumption, that, as a great nation, we must and will provide for all our wants and comforts:—no nation can be independent without it.

The objects of the Franklin Institute are the promotion of the mechanic arts; whatever, therefore, will secure these objects, whether it be in the lecture room, the laboratory, by scientific investigations, by publications, or by exhibitions of American skill—these, one and all, the Institute will most unremittingly employ.

We must be pardoned for taking this occasion to speak of the claims of the Franklin Institute upon the citizens of Philadelphia. We do not think that we can be chargeable with presumption, when we say that the Institute has claims, not only upon the manufacturer and artisan, but upon all whose prosperity is involved in the prosperity of Philadelphia.

The Institute has, thus far, been sustained mainly by the labors of a comparatively few zealous, disinterested friends of science and the arts; they have done all and more, by contributions of time and money, than could have been reasonably expected, or asked, of them. The Institute, by attempting too much, has become embarrassed, and its friends must appeal to the citizens of Philadelphia for aid to extricate it from its difficulties, or it may drag on a sickly existence, and, possibly, perish. Should our citizens permit such a result, it may then be found that Philadelphia has lost one of the chief stimulants and aids which has given the productions of her workshops a character unsurpassed, if not unrivaled, by those of any other city in the Union.

The Committee charged with the care of this exhibition would not do justice to their feelings, did they not here acknowledge their indebtedness to the gentlemen composing the Committees of Arrangement and of Judges, who contributed so much valuable time and aid.

In presenting this report, it is due to the makers of the articles deposited to say, that, with very few exceptions, the specimens exhibited are but fair samples of what may be obtained at all times from the manufacturers, or their agents—they were not made with special reference for this exhibition. And it is also proper to say that each specimen has been subjected to a rigid scrutiny, and has not only been compared with similar articles of domestic make, but has also been brought into close comparison with similar articles of old established European makers.

The judges are disinterested men, entirely independent of the parties interested in the issue, and have been selected on account of their practical acquaintance with the articles submitted to their inspection.

It is a subject of regret to the Institute that many beautiful specimens of art, which grace the exhibition, and reflect great credit on

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the makers' skill and taste, were not deposited within the time prescribed, and, consequently, could not come under the inspection of the judges.

All that we can report at this time is a list of those articles, which, for their superior excellence, have obtained the award of a premium, honorary mention, or special notice. The report of the judges, in detail, will appear in the Journal of the Institute. As the awards of premiums are read, the President of the Institute will present them to the parties entitled to receive them.

We are also instructed to say, that if any article deposited within the prescribed time, has been omitted by the judges, or, in the preparation of our report, such omission will be corrected, and the article, if entitled to an award, will be reported on immediately before the address, on the last day of the exhibition.

Report.

On the Thirteenth Exhibition of American Manufactures, held by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.

The Committee on Exhibitions of the Franklin Institute respectfully Report:—

That the exhibition, the awards in regard to which the Committee is about to publish, far exceeds any previous one held by the Franklin Institute. The labors encountered by the members, who were active on the different committees, and the exertions of the depositors have been amply rewarded by the result produced.

It was doubted by many whether the splendid accommodations which the halls of the Museum building afford, were not too extensive for the purpose of our exhibitions. With several departments of manufactures, less fully represented than might reasonably have been expected, we have had abundance from others to fill the space provided, and that bountifully, as well as beautifully. The useful and the ornamental have contended for the palm of public favor, and the throngs which have examined these specimens of native skill and ingenuity, have been more than satisfied, highly gratified, with the increased number and interest of the products set before them, and with the increased facilities for a close examination of the separate specimens.

The usual notices of the time of beginning the exhibition, and of the rules under which it would be conducted, have been rendered public for several months, thereby giving ample time for forwarding, and even preparing (in cases where it was deemed desirable,) articles for exhibition, and preventing, as far as practicable, those mistakes which sometimes deprive deserving competitors of the fruits of their skill, by nonconformity to established rules. Notwithstanding the efforts of the committee in this respect, and of those of the committee of arrangement, many depositors brought articles too late for examination, which otherwise would doubtless have met with attention, and in many cases the reward of the honors of the exhibition.

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Under these rules the exhibition opened on Tuesday last, the 17th of October. The activity of the committee of arrangement, to whom the thanks of the Institute are due, gave, at an early date, an earnest of the present happy conclusion of their labors, and if in some cases their just expectations were not realized, the experience gained will be useful on future occasions.

The manufacturers and artisans have fully met the wishes of the Franklin Institute, and of the public. The display of goods in some departments is exceedingly beautiful; the printed cotton goods have attracted universal attention, and received the highest praise; the woolens are thrown into the shade only by the cottons; the silk goods give promise that this branch of manufacture is firmly established among us; the carpets are of beautiful texture, and excellent colors, and of a considerable variety of kinds; the oil cloths, which have been improving from year to year, are admirable; the hardware and cutlery are of great variety, and excellent quality, many articles entirely superseding the use of the foreign ones; the iron and steel keeps its rank; the exhibition of lamps and gas fixtures surpasses all former ones; the stoves and grates still improve; the cabinet ware and furniture take a new rank for beauty of form and exquisite finish; the musical instruments improve greatly in average quality; the books and stationary, the bookbinders' tools, the chemicals, the straw goods, the surgical instruments, the paints and colors, maintain their rank, and some of the departments have even advanced; the hats and caps, the coach work, the leather and morocco were exhibited in quantities, and of a quality, to satisfy all; the boots and shoes are excellent; the philosophical apparatus has manifestly improved. These are among the departments which have chiefly contributed to give to this exhibition the character already assigned to it.

The committee has closely adhered to its published programme in the arrangements of the exhibition, and, aided by the promptness of the committee of judges, is now prepared, on the appointed day, to publish the awards made by them to the makers and depositors of articles examined.

In presenting the results of the reports of the judges, and of their deliberations upon them, the committee intends to be very plain in speaking of the merits, or demerits, of different departments of the exhibition. The real, substantial merits of the whole are too great to be depreciated by such a course. The committee feels too certain of this to fear. On the other hand, our mechanics and manufacturers, and the public, all of them parties whom the Institute should serve, will gain by candor. The Franklin Institute, the committee trusts, will never attempt to make capital by flattering words, or undue praise.

I.—*Cotton Goods.*

The display of Cotton Goods, especially of Cotton Printed Goods, was the pride of the exhibition, reflecting great credit on the establishments whence they came. Their tasteful display by the depositors, under direction of the committee of arrangement, rendered the spec-

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mens exceedingly effective. When the material, as well as the printing, shall be American, there can be nothing more to be desired in this department, but its regular and steady forward movement with all other branches of art. The beautiful variety of patterns, the skill in the combination of colors, the exquisite beauty of the colors themselves, could not be examined without glowing admiration.

The awards in this branch will be found liberal, in proportion to the excellence just set forth. The committee has followed closely the recommendation of the judges.

No. 2, by Benjamin Marshall, of New York Mills, Whitestown, New York, deposited by John W. Downing, fine bleached longcloths, "believed to be the best ever made in the United States," and rivaling the British longcloths. A Silver Medal.

Nos. 150 to 155, by J. Dunnell & Co., Pawtucket, Rhode Island, for beautiful printed cotton goods, "combining elegance of design, brilliancy of coloring, and accuracy of execution in an extraordinary degree," deposited by David S. Brown. A Silver Medal.

Nos. 13 and 173 to 179, by Benjamin Cozzens, Providence, R. I., for beautiful printed goods, combining the same qualities with the articles last named, deposited by Lippincott, Way & Wolcott, and by Austin Scott. A Silver Medal.

No. 202, by A. Robeson & Son, of Fall River, Mass., deposited by Hacker, Lea & Co., printed cottons and printed lawns, of qualities enumerated in the foregoing. A Sliver Medal.

Nos. 188 to 197, and 199 to 201, by Perkins & Wendell, of Bustleton, Philadelphia county, deposited by David S. Brown & Co., and by C. W. Churchman, a superb display of printed cottons and printed lawns, balzerines, and mousselines de laine, possessing the same qualities as the foregoing. A Silver Medal.

It is to be understood that the last four awards are made for the printing of the goods.

No. 49, Preston longcloths, by the Lonsdale Company, Providence, R. I., an excellent shirting, deposited by Wood & Abbott.
A Certificate of Honorable Mention.

No. 20, by R. Beath, of Philadelphia, Earlston ginghams, deposited by Sharp, Lindsay & Haines, a good article, the finish improved upon former specimens. A Certificate of Honorable Mention.

No. 40, by Hood, Simpson & Co., of Philadelphia, ginghams, in imitation of the Manchester ginghams, deposited by John Simpson.
A Certificate of Honorable Mention.

No. 47, by John Elliott, of Philadelphia, deposited by Bingham & Kintzle, well made imitation linen diaper.
A Certificate of Honorable Mention.

No. 9, by Thomas Brown, of Blockley, Philadelphia county, deposited by E. Pilling, of Philadelphia, very good striped tapes.
A Certificate of Honorable Mention.

No. 233, by James Wright, of Philadelphia, Turkey red yarn, much improved upon the specimens submitted last year.
A Certificate of Honorable Mention.

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Nos. 159 to 165, the American and Hamilton Print Works, and Joseph Ripka exhibit favorable specimens of their skill.

II.—*Woolen Goods.*

The specimens in this branch were highly creditable to the manufacturers.

The judges recommend, and the committee makes the following awards:—

Nos. 100 to 106, by S. Slater & Sons, Webster, Mass., deposited by D. S. Brown & Co., black cloths, wool dyed, beautifully finished, regarded by the judges as the best in the exhibition—a silver medal.

Nos. 117 to 122, by Edward Harris, of Woonsocket, R. I., deposited by David S. Brown & Co., merino cassimeres, very superior, and showing great improvement—a silver medal.

Nos. 58 to 95, by the Middlesex Manufacturing Company, of Lowell, Mass., deposited by Stone, Slade & Farnum, cloths and cassimeres, of good quality—a certificate H. M.

The judges notice with approbation Nos. 131 to 133, by the G[illegible] Company, Rochester, N. Y., superior blankets, deposited by David S. Brown & Co.; Nos. 134 to 144, by W. & D. D. Farnum, Waterford, Mass., deposited by D. S. Brown & Co., fancy cassimeres; No. [illegible], by James Martin, of Philadelphia, four vest patterns, considered to be beautiful specimens; No. 252, by John H. Ewing, Washington county, Penn., deposited by Farnum, Newhall & Co., four pieces of wool.

III.—*Carpets and Oil Cloths.*

Few departments of the exhibition attracted more attention than this from the intrinsic excellence of the specimens, and the superiority over exhibitions of former years.

In compliance with the indications of the judges' report, the committee awards:—

No. 21, by W. H. Knight, Saxonville, Mass., deposited by W. D. Hasting, a beautiful specimen of fine ingrain carpeting, the best exhibited—a silver medal.

No. 211, by Andrew McCallum & Co., Germantown, Philadelphia county, the best specimen of Brussels carpeting exhibited—a silver medal.

No. 25, by John Rosencrantz, Manayunk, Philadelphia county, a superior velvet-pile carpet—a silver medal.

No. 227, by Isaac Macauley & Co., of Philadelphia, oil cloths for floors, of large size and excellent quality—a silver medal.

The table oil cloths of Andrew Johnson, of Cincinnati, Ohio, No. 27, fully sustain the reputation of the manufacturer.

IV.—*Silk Goods.*

The increasing number and variety of articles in this department give evidence, year by year, of a steady and regular growth. The judges appeared to have examined the various articles minutely, and in accordance with their recommendation, the following awards are made:—

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No. 224, by John W. Gill, of Jefferson county, Ohio, a collection of silk goods of various kinds—a silver medal.

This collection includes quantities of from one to twelve yards of heavy triple piled velvet, eight thread satin vesting, figured vesting, black serge, flowered silk, colored cravats, handkerchiefs, heavy crimson, white and blue amozine, black and white silk stockings, &c. The raw silk is understood to be grown by the farmers in the neighborhood of the manufactory.

No. 30, by the New York Dyeing and Printing Company, Staten Island, deposited by Mitchell, Brognard & Co., thirty-four pieces of Pongee handkerchiefs, the printing executed in this country—a certificate H. M.

No. 50, by the Philadelphia Silk Manufacturing Company, deposited by J. C. Coppuck, one case of sewing silks, considered by the judges to be the best in the exhibition—a certificate H. M.

The judges mention with approbation, specimen No. 222, fifty pieces of union galloons, by Edward S. Richards, of Philadelphia, deposited by Piggott & Richards.

They likewise examined specimens of gloves, and speak well of No. 5, two dozen pairs of men's royal buck gloves, by John J. Taveneir, of Johnstown, N. Y., deposited by Bettle Paul, the article being one which may compete successfully with the foreign.

They recommend, and the committee awards, to 221, by Enos Cooper, of Philadelphia, one dozen and a quarter of men's kid gloves, considered to be equal in quality to the imported—a certificate H. M.

No. 273, by J. R. Ashford, of Philadelphia, six dozen of kid gloves, of a quality similar to the last mentioned—a certificate H. M.

The judges also mention with commendation No. 1, a case of silk stocks, by C. A. Walborn; No. 6, a case of raw sewing silks, by Mrs. Waples, of Sussex county, Delaware, the production of a private family; No. 907, silk suspenders, by Solomon Dœbely, of Philadelphia; No. 11, a case of satin stocks, by S. A. Sendos, of Philadelphia, some of the stocks being made of American silk; No. 97, one case of silk goods, which compare favorably with the Chinese article of the same kind, by Benjamin H. Hooley, of Philadelphia; No. 98, a lot of silk handkerchiefs printed in the United States, at the Thornton Print Works, deposited by Simpson & McGregor; No. 213, by George W. Ward, of Philadelphia, one case of fashionable stocks; No. 38, a case of stocks, by Mrs. A. J. Kneeland; No. 218, silk stocking, made and deposited by Amy Jones, of Camden, N. J.; and No. 353, by J. T. Whitecar & Co., of Philadelphia, one case of suspenders, chiefly of silk and gum elastic, and parts of which are lined with canvas.

V.—*Iron and Steel.*

The samples of Iron and Steel, submitted at the exhibition, have been carefully examined by the judges, have stood their tests well, and afford gratifying proofs of the progress of this important branch of manufacture. The judges recommend the following awards, which are accordingly made by the committee:—

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ware, and other castings of great excellence—a certif. H. M.

Nos. 1649 to 1651, deposited by Morris & Jones, of Philadelphia, an excellent collection of specimens of iron, in different stages of manufacture—a certif. H. M.

No. 1625, by J. L. Mott, of New York, a cast-iron bathing tub, of good form and size—a certif. H. M.

No. 1599, by John Robbins, jr., of Kensington, blistered steel, made from Swedish iron—a certif. H. M.

The judges speak favorably of the specimens of Round and Flat Iron, from the Colemanville Iron Works; of some of the hammered iron from William Dowling, of Mary Ann Forge, Chester county; of the nail rods from the Colemanville Works, deposited by Morris & Jones; of those from Valentine & Thomas, deposited by Isaac Miller; and from the Howard Iron Works, deposited by E. J. Etting & Brother.

The Imitation Russia Sheet-iron, by James Wood & Sons, maintains the high character which induced the Institute to award to it a silver medal at the last exhibition. The attempt of Mr. Thomas Speakman, of Philadelphia, to imitate the Russia iron, is mentioned as worthy of encouragement. The sheets of Boiler Iron, deposited by William F. Potts, and made by S. Hatfield, also those deposited by Morris & Jones, are commended by the judges.

The report of the judges will be published in full.

VI.—*Umbrellas, Etc.*

The display of Umbrellas, Parasols, and Sun Shades, was creditable to the manufacturers. In accordance with the tenor of the observations of the judges, the committee awards:—

No. 268, by Messrs. W. & W. H. Richardson, of Philadelphia, for an assortment of parasols and sun shades, a new pattern—a certif. H. M.

No. 247, by W. A. Drown, of Philadelphia, for an assortment of parasols and sun shades—a certif. H. M.

VII.—*Lamps and Gas Fixtures.*

The display of these articles has never been surpassed in beauty at any former exhibition. The judges devote a considerable portion of their report to a notice of the beautiful articles which formed the greater, as well as the most admired, part of this collection, produced by Cornelius & Co. The richly ornamented gas pendants in ormoulu, and the silvered chandeliers and candelabra are particularly referred to, as well as the solar and lard lamps from the same manufactory. This report will hereafter be published; the committee now awards in accordance with its recommendation:

Nos. 1235 to 1242, by Cornelius & Co., of Philadelphia, a rich display of chandeliers, candelabra and lamps, the forms of which were truly beautiful—a silver medal.

No. 728, by E. Whelan, of Philadelphia, a pair of silvered candelabra—a certif. H. M.

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No. 1257, by J. S. Gold, of Philadelphia, an assortment of camphine lamps and chandeliers—a certif. H. M.

No. 1372, by Ellis S. Archer, of Philadelphia, various lard lamps—a certif. H. M.

No. 656, by Filley & Kisterbock, of Philadelphia, for various lard lamps—a certif. H. M.

VIII.—*Hardware and Cutlery.*

Notwithstanding the number and variety of the articles exhibited in this line, they appear to have received close and careful examination. The Committee of Judges, as in so many other cases, regrets that many specimens were brought to the exhibition too late to come under their notice.

The judges recommend, and the committee sanctions, the following awards:—

R. & W. Robinson, of Attleboro', Mass., for No. 634, deposited by Colladay & Brother, one case of gilt metal buttons, of exquisite finish—a silver medal.

Ibbotson & Horner, of New York city, for No. 725, deposited by Savery & Co., one box of horse rasps, and three square files, of excellent material and workmanship, eighteen dozen of three square files, of assorted sizes, being exhibited—a silver medal.

The following named articles, which received premiums at the last exhibition, are spoken of as fully sustaining the character then acquired:—The wire cloth, No. 620, by J. Mecredy, of Philadelphia; the files and rasps, No. 621, by G. Machin, of Philadelphia; the pocket and pen knives, No. 633, by Bradley & Beecher, of Naugatuck, Conn., deposited by Heaton & Denckla; the screws, No. 682, made by the New England Screw Company, Providence, R. I., and deposited by Curtis & Hand.

The following awards, recommended by the judges, are also confirmed.

Wadhams, Webster & Co., of Wolcottville, Connecticut, No. 616, a case of gilt buttons, beautifully finished—a certif. H. M.

H. Huber, jr., Philadelphia, for No. 644, one case of saddlers' tools, highly commended by the judges—a certif. H. M.

W. Reed & Co., of Philadelphia, for No. 675, one card of brass cocks, of superior workmanship—a certif. H. M.

No. 1705, Savery & Co., of Philadelphia, for butt hinges and sad irons, of an admirable quality and appropriate finish; the butt hinges being considered the best exhibited—a certif. H. M.

A number of specimens of butt hinges were presented for competition, and the judges speak favorably of No. 661, a card of cast-iron butt hinges, by J. L. Johnson, of Philadelphia, deposited by Steinmetz & Justice; of No. 662, a similar article, by Thomas Loring, of Philadelphia, deposited by W. Hart Carr; of No. 701, the same article, by Stewart, Biddle, Lloyd & Co., of Danville, Penn., deposited by W. P. Cresson & Brother.

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Special notice is taken of No. 694, one case of saws, and one circular saw, by J. Wood & Sons, of Philadelphia; of No. 703, locks of a peculiar construction for mortise door locks, by T. L. Littlefield, of Philadelphia.

This latter article should be referred for examination to the Committee of Science and the Arts.

The following articles are also noticed with approbation by the judges:—

No. 627, six pair of iron chains, made by J. & E. M. Smith, of Hamburg, Pa., and deposited by Shipley & Warner.

No. 629, well finished coopers' tools, by Barton & Smith, of Rochester, N. Y.

No. 645, five rifles, by John Krider, of Philadelphia, deposited by J. T. Siner, fully sustaining the reputation of the maker.

No. 659, planes made by David Colton, of Philadelphia, the best specimens exhibited.

No. 663, iron and tinned iron rivets, by Holmes, Edes & Co., of North Marshfield, Massachusetts, deposited by Heaton & Denckla.

No. 712, a well made rifle and appliances, by T. T. Subers, of Philadelphia.

No. 715, four scythes, by O. Hunt & Brother, of Stavesville, deposited by Heaton and Denckla.

No. 716, six scythes, by Inman & Co., of Slatersville, Pa., deposited by Heaton & Denckla.

The judges remark that the home manufactured scythes have entirely superseded the use of the imported articles.

The articles of Britannia Ware are thought by the judges to give earnest of improvement; they particularly mention No. 654, by J. H. Palethorp & Co., of Philadelphia, and No. 657, by Boardman & Hall, of Philadelphia.

The excellent locks of Prutzman came too late for competition.

IX.—*Saddlery, Harness, and Trunks.*

The judges are of opinion that there should have been a greater variety in the articles in this department, to have given a fair representation of the condition of the art. The articles deposited were, however, generally of a good quality. In conformity with what is understood to be the recommendation of the judges in the report, the committee awards:—

No. 328, by James E. Brown, of Philadelphia, well made trunks—a certif. H. M.

No. 380, by Jacob Moyer, of Philadelphia, a beautiful traveling trunk—a certif. H. M.

No. 366, by E. P. Moyer, of Philadelphia, a well made trunk—a certif. H. M.

No. 352, by John Unruh, of Philadelphia, a traveling trunk with white nails, beautifully finished—a certif. H. M.

The harness by Lacy, sustains, in the opinion of the judges, his high reputation. A leather trunk, by Adriance, No. 342, is spoken

of with praise, also both specimens of medical bags, by S. F. Summers, No. 315, and by A. M. Martin, No. 389.

The assortment of Whips was good.

The Harness Ornaments, No. 362, of J. Welsh, of Philadelphia, deposited by S. R. Phillips, are worthy of notice.

X.—*Models and Machinery.*

The collection of Models and Machinery was not such in quantity or variety as fairly to represent the condition of the Mechanic Arts; even in our city. There can be no doubt that our workshops have felt the influence of the depressing circumstances of the years just past, but there can also be no doubt that a much more creditable display might have been made, had our workmen felt more fully that their interest and reputation were at stake. Whole branches known to be in active operation were unrepresented by even a single machine. This is the more to be regretted that considerable expense was incurred to provide most ample accommodation for heavy machinery. It is true that many of the articles exhibited were highly creditable to the manufacturers, and that after the date at which, by the rules of the Institute, notice could be taken of specimens, many excellent articles were brought into the rooms, but still this department of the exhibition was not what it might have been. The committee submits to the Philadelphia mechanics whether this state of things is fair to the Institute, or to the public, and hopes that on another occasion this department will bear quite a different character.

The judges recommend, and the committee makes the following awards:—

No. 1538, by James & Joseph Albertson, of Philadelphia, a skiff, with an oak frame and cedar planking, of beautiful workmanship—a silver medal.

No. 1631, by Charles Evans, of Philadelphia, copying presses, of excellent workmanship—a silver medal.

No. 1503, by James Brooks, of Frankford, Pennsylvania, a horizontal steam engine, a good and serviceable piece of work—a certif. H. M.

No. 1504, by J. W. & J. F. Starr, of Kensington, a locomotive boiler, considered to be an excellent specimen of work—a certif. H. M.

No. 1530, by E. G. & R. O. Tripp, of Trenton, N. J., deposited by A. Quintin, of Bristol, Penn., a box of shuttles—a certif. H. M.

No. 1531, by J. D. Dale, of Lansingburg, N. Y., deposited by Gray & Bennett, of Philadelphia, four platform scales—a certif. H. M.

No. 1577, by Stephen Ustick, of Philadelphia, a log brace for saw mills—a certif. H. M.

No. 1582, by Jacob Lodge, of Philadelphia, an apparatus for corking bottles to contain effervescing waters—a certif. H. M.

No. 1583, by D. O. Prouty & Co., of Philadelphia, a sub-soil plough—a certif. H. M.

No. 1626, by Jordan L. Mott, of New York, a stationary cowl, or ventilator, shown by the experiments of Mr. Ewbank, to answer its purpose well—a certif. H. M.

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coolers and filters—a certif. H. M.

No. 1618, by John McConn, of Philadelphia, deposited by Carter & Parham, hatters' heating irons—a certif. H. M.

No. 1619, by George Snyder, Philadelphia, for well shaped, smooth, and dense bricks—a certif. H. M.

No. 1654, by G. W. Metz, Philadelphia, for a well made blacksmith's bellows, with a new mode of inserting the pipe—a certif. H. M.

No. 1661, by Joseph Laubach, deposited by John Murphy, a patent blacksmith's tuyere, furnishing an efficient blast from the bottom of the fire—a certif. H. M.

No. 1665, by William Elliott, Francisville, near Philadelphia, a model of a hipped roof, slated with specimens of different kinds of work of excellent finish—a certif. H. M.

No. 1689, by Greer, Amer & Newell, Philadelphia, a small steam engine, well contrived and executed—a certif. H. M.

The lathe of John H. Schrader, reported by the judges for a certificate, was too late for competition.

To Gideon Cox, Philadelphia, for the deposit of various specimens of wooden ware for household use—a certif. H. M.

To Landreth & Munns, Philadelphia, for an exhibition of agricultural implements and tools—a certif. H. M.

To D. O. Prouty, Philadelphia, for an exhibition of similar articles—a certif. H. M.

To Edwin Chandler, Philadelphia, for a similar display of implements—a certif. H. M.

To James Young, Philadelphia, patent agent for a number of ingenious machines, deposited by him—a certif. H. M.

The utility of establishments like these, where agricultural and other implements and machines for various purposes may be found by purchasers, who often require advice in regard to their choice and use, induces the committee cheerfully to make awards to these gentlemen for the variety of specimens deposited by them.

The judges are of opinion that the self-adjusting counter spring, by Oliver Evans, of Philadelphia, and Cottrell's lattice weighted bridge, should be presented by their inventors for the examination of the Committee of Science and the Arts.

The minute report on this department will be hereafter published; it closes with a regret that many articles of value were deposited too late for competition, or notice.

The judges speak approvingly of No. 1570, by J. Dutton, Delaware county, an apparatus for distributing water in thin sheets, to promote its freezing; of No. 1596, by George W. Duncan, Philadelphia, an abridged set of stencil plates for marking; of No. 1598, by William M. Davis, Philadelphia, a small lathe of good workmanship; No. 1634, by Ellis Jackson, Philadelphia, well made shuttles for weavers; No. 1640, by Jacob Senneff, Philadelphia, a power loom shuttle, of neat workmanship; No. 1702, by Mahlon Gregg, Philadelphia, a machine for cutting tenons.

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XI.—*Stoves, Grates, Etc.*

The spirited competition which exists in these important articles, always secures an excellent display of them at our exhibitions. On the present occasion the means of exhibiting practically the good qualities of the Stoves and Ranges, were as ample as could possibly be desired. The detailed report of the Committee of Judges will be published in the Journal of the Franklin Institute, thus furnishing more minute information in regard to the several articles exhibited, than can be given in the compass of this report.

Upon the recommendation of the judges, the following awards are made:—

No. 1501, by Pleis, Fœring & Thudium, Philadelphia, for a radiator stove—a certif. H. M.

No. 1620, by Jacob F. Pleis, Philadelphia, for a radiator stove—a certif. H. M.

No. 1707, by Weaver & Volkmar, Philadelphia, for a radiator stove—a certif. H. M.

No. 1720, by Williams & Hines, Philadelphia, for a radiator stove—a certif. H. M.

No. 1714, by J. W. Kirk, Philadelphia, deposited by Williams & Hines, for a crescent radiator, of new and curious arrangement—a certif. H. M.

No. 1721, by A. Brenizer, Philadelphia, for an air-tight stove, for wood—a certif. H. M.

The Ornamental Stoves, as well as the Cooking Stoves and Ranges, resembled very much those exhibited during the two years last past.

Farther awards are made, on the recommendation of the judges.

No. 1603, a cooking stove, by S. R. Sank, deposited by T. Durell—a certif. H. M.

No. 1698, a cooking stove, by J. Kisterbock—a certif. H. M.

No. 1686, a summer stove and baker, by M. Stewart—a certif. H. M.

No. 1528, by Lloyd & Feltwell, Philadelphia, a cooking range—a certif. H. M.

No. 1557, by Julius Fink, Philadelphia, a cooking range—a certif. H. M.

The two ranges just named have taken a premium at former exhibitions, and can, therefore, now, according to rule, have no other testimonial than the certificate, which shows them so far to be in the first rank.

No. 1534, a cooking range, by F. McIlvaine, Philadelphia—a certificate H. M.

No. 1567, a cooking range, by Henry Hallman, Philadelphia—a certif. H. M.

To Jordan L. Mott, New York, for the extensive and creditable display of stoves, furnaces, boilers, &c., deposited by De Witt C. Mott—a certif. H. M.

No. 1559, by C. W. Warnick, Philadelphia, for a similar exhibition—a certif. H. M.

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The specimens of Cabinet Ware exhibited this year, fully sustained the reputation of our manufacturers, which is deservedly very high; it was, however, a subject of remark that on an occasion where so excellent an opportunity for the display of a large number of articles had been provided, by furnishing ample space for exhibition, the number fell short of those of the exhibition of last year. In the opinion of the judges, many of the articles exhibited were beautiful models of taste, ingenuity, and excellent construction, challenging competition, especially in the last named quality.

The committee makes the following awards, recommended by the judges:—

Nos. 1319 to 1321, by J. & A. Crout, Philadelphia, a centre table, and other articles of American woods—a silver medal.

The committee particularly recommend this branch of art to the fostering care of the Institute, and are of opinion that the specimens just named are not excelled by the productions of the like sort in any country, in regard to which they have had full opportunities of being informed.

Nos. 1330 to 1332, by Charles H. & J. F. White, Philadelphia, articles of furniture in the Gothic style, of excellent workmanship, and tasteful design—a silver medal.

Nos. 1222 to 1225, by Alphonse Quantin, Philadelphia, deposited by A. Lejambre, furniture in the style of Louis XVI, (renaissance) of rich materials and good workmanship—a certif. H. M.

No. 1293, By Benjamin J. Williams, Philadelphia, Venetian blinds, of good construction and excellent finish—a certif. H. M.

The specimens of painting in wood, by John Gibson, exhibited in numerous articles, were much admired. The committee awards a certificate of H. M.

XIII.—*Musical Instruments.*

Superior facilities were afforded this year for the exhibition of Musical Instruments, and the number and variety were considerable. The judges are of opinion that most satisfactory proof was afforded of progress in this branch of art. The elaborate report of the judges will be published in the Journal of the Institute. The Committee on Exhibitions having maturely weighed the subject, and compared the principles which govern the award of the honors of the Institute in other departments, with those laid down by the judges, in reference to their recommendations in this, are constrained to raise the grade of award to different competitors, while the comparative scale presented by the judges is strictly adhered to. The committee, therefore, awards:

No. 209, A, by Messrs. Gale & Co., New York, deposited by J. C. Smith, a piano, considered by the judges to be one of the two best of its kind in the exhibition—a silver medal.

No. 1271, by Conrad Meyer, Philadelphia, a piano, deemed by the judges to be one of the two best of the kind in the exhibition—a silver medal.

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it by the judges, that the committee does not hesitate to award to No. 1302, by Thomas Loud, Philadelphia, a grand piano, combining various excellencies of construction—a certif. H. M.

The committee further awards to,

No. 1346, by C. F. Martin, Nazareth, Pa., deposited by F. Peale, a Spanish Guitar, of graceful proportions, and very fine tone—a certificate H. M.

The judges speak with praise of the seraphina, No. 1178, by Chris. Knaurr, and the case of wind instruments, No. 1266, by Thomas W. Weygandt; of the pianos of the Philadelphia Manufacturing Company, Messrs. Groves, Loud, Miller, Reichenbach, and Betts.

The committee also awards to

No. 1201, a parlor organ, by Henry Corrie, deposited by James Cox, novel in some of the arrangements, and of good tone—a certif. H. M.

The parlor organ, No. —, by Joseph Buffington, deserves notice as the highly creditable work of a self-taught young man, who has devised and executed every part of it without assistance, or other instruction than he could derive from books, and the occasional conversation of a friend.

XIV —*Glass and China.*

The display in this department was not equal to that at the last exhibition, nor did it do justice, much less credit, to the sate of the manufacture in the country. The judges very justly remark that "Philadelphia furnishes a market for a large amount of Glass Ware, and the manufacturers of the article would certainly have advanced their interests had they submitted to the public, through the exhibition, a better variety of what they were capable of producing in their respective factories." In pursuance of the recommendation of the judges, the committee awards:

No. 601, made by P. C. Dummer & Co., of Jersey City, deposited by E. E. Smith, a cut glass bowl, of graceful form and good finish, and of a superior quality of material—a silver medal.

No. 713, by the New England Glass Company, Boston, deposited by S. D. Hastings, several pairs of cut glass salts—a certif. H. M.

No. 614, made by T. Richards, Philadelphia, samples of window glass, of pure material, and free from waves—a certif. H. M.

The judges speak in terms of high praise of No. 646, samples of pottery from the manufactory of Abraham Miller; but as Mr. Miller is one of the Board of Managers of the Institute, the rules forbid any award in this case. They also commend No. 722, specimens from the American Pottery Company, Jersey City. The Committee of Exhibitions refers to the report of the judges, which will be published hereafter, for excellent remarks in reference to this useful branch of manufacture.

No. 652, a cut glass decanter, with nine compartments, was much admired.

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The display in this department has fallen off at the last two exhibitions; a wrong done by manufacturers to themselves, as well as to the public. The judges have not recommended any special awards, but from the terms of their report the committee awards:

No. 180, by S. Moore, Philadelphia, deposited by Carey & Hart, books in a great variety of bindings, remarkable for neatness of execution, and good taste—a certif. H. M.

The case in the Gothic style, in which these books were contained, by J. Blair, the painting by Gibson, was much admired.

No. 1289, a map of the United States, by Mitchell, the smaller size, done on wood and stereotyped—a certif. H. M.

The judges speak in commendation of No. 19, a map of the United States, by Sherman & Smith; No. 210, well made slates, from Samuel Taylor, Easton, Pa.; No. 1550, slate pencils, of admirable material, but too roughlyfinished; No. 1203, a map of Philadelphia county, by J. H. Young; No. 212, deposited by J. B. Lippincott & Co., American elastic inkstands, of various sizes; No. 254, wood type, for fancy work, by Wells & Webb, New York; No. 26, by Lindsay & Blakiston, a number of beautifully bound books.

The committee coincide entirely with the judges in their expression of disapprobation, in regard to the foreign stamps and names put by some of our manufacturers upon their goods.

XVI.—*Paper Hangings.*

At the last two exhibitions, this department attracted much of the attention of visiters, from the number and excellence of the specimens. The results to the manufacturers were immediate. On the present occasion the specimens show that there has not been a falling off in the quality of the articles, but the quantity was too small to excite attention. This is the more to be regretted when the present rooms offer so excellent an opportunity for the display of wall papers. The committee hope that the public may be more respectfully considered on a future occasion.

XVII.—*Fine Arts.*

The subjects more particularly appropriate to an exhibition like ours, are not those which constitute the most attractive parts of a picture, or statue, gallery. It is difficult, however, to draw the line between the appropriate and inappropriate, and when artists of merit, in the higher walks of the fine arts, submit their productions to the public through the medium of our exhibitions, it is right to acknowledge their sense of their merits. The committee awards as follows:

No. 1221, by G. W. Conarroe, Philadelphia, a portrait of the Hon. Calvin Blythe, and a portrait of a lady—a certif. H. M.

No. 1215, by W. Warner, Philadelphia, a collection of mezzotint engravings—a certif. H. M.

The "Arm Chair," a picture by Mr. Warner, referred to by the judges, was too late for notice.

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Nos. 1279, 1280, and 1294, portraits in water colors, by M. S. Parker—a certif. H. M.

The judges speak in terms of praise of the design for a monument, and for a fountain, by J. C. Trautwine, and of the water color drawings, by Wm. Mason, and of the wood engravings generally.

The committee award No. 1267, by C. B. Ives, Philadelphia, for a marble bust—a certif. H. M.

The committee notice with commendation the collection of Daguerreotype miniatures, No. 1317, by J. Plumbe, jr.

The splendid full length picture of Henry Clay, for which the exhibition was indebted to Mr. Neagle, was deposited too late to be noticed by the judges.

XVIII.—*Silver Ware and Jewelry.*

The number of articles of Silver Ware exhibited this year was considerable, and their finish admirable. The exhibition of Jewelry, on the contrary, was smaller. The judges recommend the following awards, which are made accordingly:

No. 642, by Messrs. R. & W. Wilson, Philadelphia, containing two plain tea-pots, and a pair of oyster dishes, particularly noticed as showing good hammering and fitting—a certif. H. M.

The judges refer particularly to a pitcher of chased work, No. 608, by Bard & Lamont, commending the mechanical execution, while they disapprove of the design. They are of opinion, that, in general, in this branch, purity of design, and perfection of form, are not sufficiently studied. Without these, exquisite polish, and beautiful chasing serve but to cover defects which they cannot hide.

XIX.—*Bookbinders' Tools.*

The competition in this branch is always very limited, from the intrinsic circumstances of the art itself. The specimens at this exhibition fully sustain the high reputation of those depositors whose specimens came in time to be examined by the judges, under the published rules of the exhibition.

The judges mention especially the brass tools of Messrs. Gaskill & Copper; a steel embossing plate, by A. C. Morin; the designs by Chapman, Persell & Thompson, of New York, and the steel plates for engravers, by the same firm.

XX.—*Marble Work.*

There were so few articles in this line in the exhibition as to produce general surprise; the meagre collection not corresponding to the known variety of Philadelphia marble work.

The judges speak favorably of, and the committee awards a certificate of honorable mention to No. 1292, a mural tablet, by Ferd. H. Strecker.

XXI.—*Hats and Caps.*

The display in this department was admirable indeed, far surpassing even that in 1840, when there was so much competition among

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eral, that after their minute examination they are at a loss to recommend awards which shall place one competitor above another. Their minute and well prepared report will be published for the information of all concerned, and the committee hopes that the hints given in it will not be lost upon manufacturers in this line. The committee regrets that they cannot comply with the wishes of the judges in regard to articles deposited after 12 o'clock on Tuesday last, even under the very strong circumstances which they present: the rule must be absolute, or it must give rise to exceptions which no impartiality, or sagacity, on the part of the Committee of Exhibitions could meet.

In accordance with the explicit recommendations of the judges, the committee awards:

No. 976, by Orlando Fish, New York, deposited by C. A. Walborn, three nutria and three moleskin hats—a certif. H. M.

No. 997, by John C. Yeager, Philadelphia, hats of "neat appearance, excellent color, and moderate prices"—a certif. H. M.

No. 1072, by E. Kimber, jr., Philadelphia, a case of hats, two fur bonnets, and a fancy hat for a child—a certif. H. M.

Special praise is given by the judges to the following named among the depositors whose goods were in the hall in due time:—to John Hill, Philadelphia, for a nutria and a moleskin hat, of good finish and color, and very light; to Mrs. Hill, Philadelphia, for two children's caps; to Oliver Brooks, Philadelphia, especially for his cassimere hats; to Messrs. Lamberti & Blynn, for a case of hats, distinguished for neatness of style.

The beautiful case of hats, by Charles Bulkley, was too late for competition.

The judges trace the improvement in this branch of manufacture to the competition in trade, and particularly to the stimulus afforded by the exhibitions of the Franklin Institute. Those who do not succeed in obtaining praise at one exhibition, have but to make the requisite improvement to attain this result the following year, and all have an opportunity to exhibit their goods to thousands of examiners who may become purchasers.

XXII.—*Combs and Brushes.*

The competition in these articles was very small, and the judges do not recommend any special awards.

XXIII.—*Coach Work.*

The specimens in this branch of art were very beautiful. Many were remarkable for taste of model and coloring, and for ingenuity of construction, combining strength with lightness. The judges specially commend the following articles, to which awards are made:

No. 1593, by Joseph Glenat, an omnibus for thirty passengers, sixteen feet long, of superior workmanship, and admirably contrived for the purpose of a pleasure omnibus—a silver medal.

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No. 1565, by A. Knowles, Philadelphia, deposited by the maker, the best York wagon in the exhibition—a silver medal.

The judges speak with commendation of the workmanship of No. 1551, by George Jeffries, and of No. 1552, by Ogle & Watson, both Rockaway wagons; of No. 1553, a coach, by Ogle & Watson; of No. 1653, a York wagon, by Vansciver & Sons; of the construction of No. 1555, a bow spring carriage, by A. Merritt, Philadelphia.

They also approve of No. 1541, patent harness, by L. Houghton, Boston, deposited by J. Young; of No. 1680, turned spokes, by S. Bedford, Newark, N. J., deposited by H. & J. Fricke; of No. 1681, hardened taper axles, deposited by H. & J. Frick; of No. 1691, taper coach axles and tight boxes, by Greer, Amer & Newell.

XXIV.—*Leather and Morocco.*

The judges speak in terms of high commendation of the exhibition in this department. Where so much excellence exists, it is diffiult to determine between the claims of the several artisans, but the beautiful display which has been brought forward, deserves to be marked by a generous notice. The committee accordingly make the following awards:

Nos. 302 to 304, by Fritz & Williams, Philadelphia, specimens of Morocco—a certif. H. M.

No. 318, by Charles B. Williams, Philadelphia, sides of sole leather —a certif. H. M.

No. 386, by the Boston Manufacturing Company, deposited by John W. Patton, Philadelphia, specimens of patent leather, of beautiful finish—a certif. H. M.

No. 391, by Taylor & Kinsey, Philadelphia, for half a dozen of Madras French Morocco—a certif. H. M.

No. 399, by Scattergood & Boustead, Philadelphia, for six sides of Russet bridle leather—a certif. H. M.

The following articles are noticed with special commendation. No. 321, one chaise hide, by C. & W. Pyle & Co., Wilmington, Del., deposited by J. L. Webb; No. 329, two sides of slaughter sole leather, by John W. Patton, Philadelphia; No. 371, one side of enameled top hide, by J. & R. Ward, of Newark, N. J., deposited by Thomas Mogridge; No. 384, eight calf skins, by C. & A. Dannaker, Philadelphia; No. 392, one goat skin, and one buck skin, by John Ebert & Son, Frederick, Md., deposited by C. A. Walborn; No. 397, two bag-hides, by Scattergood & Boustead; No. 398, six hides of ladies' dressed sole leather, by Scattergood & Boustead, Philadelphia; No. 401, parchment and morocco, by Doyle & McNeeley, Philadelphia; and No. 402, a lot of leather, by Fidel Fisher, Philadelphia.

The number and excellence of the articles now submitted, fully make up for the meagre display upon which the Committee on Exhibitions of last year felt it to be their duty to comment.

XXV.—*Boots and Shoes.*

The report of the judges is very specific in regard to the awards, and the committee makes them in accordance with it.

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rability, comfort, and good taste—a silver medal.

No. 357, deposited by John Ryan, a case of fancy boots, displaying good workmanship—a certif. H. M.

XXVI.—*Chemicals, &c.*

The display of Chemical preparations, and of articles submitted with them to the examination of the judges, was highly creditable, superior, in fact, in number and variety of articles to the collection of any former year. The judges have made a very full report, which will be published for the satisfaction of the depositors, and the information of the public.

The judges recommend, and the committee makes the following awards:

No. 309, by Messrs. Wetherill & Brothers, Philadelphia, for a suit of chemical preparations, of great excellence—a certif. H. M.

No. 335, by Messrs. Smith & Hodgson, for the general excellence of the specimens—a certif. H. M.

No. 327, by Lawrence Turnbull, Philadelphia, deposited by Frederick Brown, for the general excellence of the articles—a certif. H. M.

No. 613, by Edward Parrish, Philadelphia, a case of Pharmaceutical preparations, designed for the use of students of medicine—a certif. H. M.

No. 635, by Stephen Heintz, Malaga, N. J., deposited by L. Voigt, a lot of chemical glassware, of approved forms and quality—a certif. H. M.

No. 306 to 308, by Lovering & Co., Philadelphia, loaves and jars of sugar, refined without the use of blood—a certif. H. M.

No. 373, by Charles W. Gschwind, Philadelphia, for beautiful specimens of glue—a certif. H. M.

No. 388, by Hancock & Mann, Baltimore, deposited by White, Warner & Co., for beautiful specimens of their "adamantine candles" a certif. H. M.

No. 351, by Campbell Morfit, Philadelphia, a series of specimens exhibiting the process of manufacture of candles from stearine without saponification—a certif. H. M.

The judges speak in terms of high commendation of the industry shown by Mr. Morfit, in perfecting this important branch of manufacture.

No. 338, by Eugene Roussel, Philadelphia, an admirable exhibition of fancy soaps and perfumery—a certif. H. M.

The judges speak in terms of praise of the chemicals submitted by Messrs. Harrison & Brother; of the acetate of lead, from Mordecai Lewis; of the cyanide of potassium, from H. W. Worthington; of the isinglass, from C. Delacour. Also of the fancy soaps, by Curtis Taylor & Son, and the perfumery, by N. B. Hinton, and by Jules Hauel.

No. 382, by Gerhard Schmitz, Philadelphia, for specimens of chocolate—a certif. H. M.

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XXVII.—*Philosophical Apparatus.*

The display in this department was unusually creditable to the depositors, though the number of those depositing was smaller than on former occasions. The following awards, recommended by the judges, are made by the committee:

No. —, a four feet transit circle, by W. J. Young, Philadelphia, of beautiful workmanship—a certif. H. M.

No. 688, &c., by J. Bishop, Philadelphia, two electrical machines, and other apparatus—a certif. H. M.

No. 709, by James Duffey, Philadelphia, balances for hydrostatic and other purposes—a certif. H. M.

No. 1335, dew point and wet bulb hygrometers and magnetic instruments, by Solon W. Hall, Philadelphia—a certif. H. M.

No. 186, a globe and planispheres, with geographical, &c. lines, for instruction in geography and astronomy, by the Rev. R. Piggot, Maryland—a certif. H. M.

The judges mention with approval No. 708, models of machines, by James Duffey, jr., Philadelphia; No. 360, shades for magic lanterns, by Thomas A. Nolens, Rochester, N. Y.; and No. 700, the dial of the seasons, by Thomas Fisher, Philadelphia.

The neglect of Mathematical and Philosophical Instrument makers to show to the many strangers and citizens who attend our exhibitions, specimens of their handiwork, is commented upon by the judges, with whom the committee fully agree as to the bad policy of the course.

XXVIII.—*Straw Goods.*

The report of the judges upon these articles will be published hereafter. The committee confines itself to making the awards indicated by the judges:

No. 214, by A. Caseli, New York, specimens of Amazon braid, "purely white, even in texture," and of good quality—a certif. H. M.

The judges notice also with approval, No. 215, Amazon braid bonnets, by S. D. Hall & Co., New York.

Some of the best articles in this department came too late for competition.

XXIX.—*Surgical Instruments.*

The articles classed under this head have been examined with great care. In conformity with the report of the judges, the committee awards as follows:

No. 707, by M. S. Foster, Trenton, N. J., a set of porcelain teeth, of unusual excellence—a silver medal.

No. 697, by Henry Habermehl, Philadelphia, an artificial hand and legs—a certif. H. M.

No award can be made for No. 672, an abdominal supporter, by Messrs. Wiegand & Snowdon, as Mr. W. is a member of the Board of Managers of the Institute.

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chiefly dental—a certif. H. M.

XXX.—*Gum Elastic Goods.*

There was no competition in these articles generally, but the judges were much struck with the perfection of the articles exhibited by Mr. Thornley, and recommend the following award, which the committee makes:

No. 332, by J. Thornley, Philadelphia, India rubber goods, of admirable quality—a certif. H. M.

The judges speak particularly of the gum elastic over shoes with leather soles, with gum elastic shanks to leather soles; of the gum elastic air mattrasses, and cloth for signs, all contained in the lot just mentioned.

They praise also the shoes, with gum elastic soles, made by John S. Ripley, Philadelphia.

XXXI.—*Copper, Brass, and Plumbers' Work.*

The assortment under this head was small. The judges mention No. 1529, seven specimens of copper and brass ware, by W. B. Bentley, Philadelphia, as deserving commendation; also No. 1536, a lot of braziers' solder, by William Kent, Philadelphia, as of good color and well grained.

They refer in terms of high commendation to the lead pipe, made by Messrs. Tathem & Brothers, Philadelphia, which has already received a medal from the Institute.

XXXII.—*Tin Work.*

The judges report that there was nothing worthy of special attention in this line deposited in the exhibition.

XXXIII.—*Paints and Colors.*

The decisions in reference to relative merit in this department, are difficult to make in the short time allowed by an exhibition. The judges have applied such practical tests as the time permitted, and speak with praise of the following articles:

No. 309, by Wetherill & Brothers, of chrome yellow, of excellent color; No. 409, chrome green, by C. J. Crease; No. 343, red lead and orange mineral, of superior fire, by George Uhler; No. 355, coach varnish, by Wm. M. Humes; No. 325, Osborne's water colors, deposited by Smith & Hodgson; No. 364, rose pink, of superior color, by Charles Hasse.

No. 334, lamp black, by Wainwright & Elliott. The uncalcined lamp black is pronounced to be rather superior, and the calcined, very superior to the English article—a certif. H. M.

The white lead exhibited was of a superior quality; the judges mention particularly a specimen by Wetherill & Brothers, which they recommend to the attention of artists.

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The committee awards to No. 309, by Wetherill & Brothers, the smaller samples of white lead, which may, in the opinion of the judges, supersede the Kremnitz white—a certif. H. M.

XXXIV.—*Fancy Articles.*

This department, as usual, presents articles of very different grades of merit. The judges state that they have examined all carefully, and report those which they consider best worthy of notice. Awards are made to the following named articles:

No. 901, by Thomas B. Smith, Philadelphia, an admirable assortment of pickles, of various kinds—a silver medal.

No. 945, by A. Rudduck, deposited by J. M. Bolton, one case of pearl work, the carving upon which is deemed of excellent quality—a certif. H. M.

No. 951, by Philip Dolflien, Philadelphia, a miniature equestrian statue of Napoleon, in bronze—a certif. H. M.

No. 961, by Sarah Bringhurst, Philadelphia, a knitted bonnet and shawl—a certif. H. M.

No. 999 by W. H. Schreiner, two cases of artificial bait, consisting of flies, "grey hackle," and shrimps, considered by the judges as equal to the English—a certif. H. M.

No. 1009, by J. Doughty, for excellent preserves—a certif. H. M.

No. 1020, by Thomas Bogue, a gossamer wig ,weighing only one ounce, and of admirable finish—a certif. H. M.

No. 182, by C. A. Walborn, a beautiful specimen of corded collars —a certif. H. M.

No. 266, by Mrs. Wright, a linen shirt, the work upon which was much admired—a certif. H. M.

No. 1065, by Miss Johnson, Philadelphia, a splendidly embossed velvet bonnet—a certif. H. M.

No. 1077, by Joseph Sholl, an apiary, of ingenious construction—a certif. H. M.

No. 982, by James Keefe, Philadelphia, three boxes of vermicelli and maccaroni, of excellent quality, the only specimen ever exhibited —a certif. H. M.

No. 984, by Mrs. Ida Neher, Philadelphia, the best specimen of hair work on ivory—a certif. H. M.

The committee awards:

To the pupils of the Pennsylvania Institution for the Instruction of the Blind, for manufactures of tow cloth, rag carpet, rope and baskets —a certif. H. M.

The judges mention with approbation a number of articles.

No. 980, a beautiful specimen of worsted work, by Miss Seeger.

No. 1025, a similar, of raised worsted work, by Mrs. C. R. Fling; No. 1042, a frame of needle work, by Miss Prettyman; No. 985, a wreath and ottoman, by Miss A. Supplee.

The soda water of Eugene Roussel, with the peculiar fastening of the corks to present the escape of gas, fully sustains the high reputation of the article.

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No. 12, a case of ready made linen, by Mrs. S. Sendos.
" 167, " " " P. Chapouty.
" 187, " " " G. W. Ward.
No. 1028, a case of pearl work, B. & A. Waiter.

The committee further awards to

No. 651, by Capewell & Brother, for excellent specimens of sweet chocolate—a certif. H. M.

In conclusion, the committee returns thanks to the judges generally for their promptness in examining and reporting upon the departments confided to them. An unusual number of these reports are prepared with a care which renders them worthy of being presented to the public, and the committee will recommend them for insertion in the Journal of the Franklin Institute; thus, all defects which may be found in the present document will be remedied, and minute information be given in regard to articles, and departments of interest.

The certificates are ready for delivery, and the medals which have not been delivered may be had at the office of the Actuary.

To be Continued.

Mechanics, Physics, and Chemistry.

GLEANINGS FROM FOREIGN JOURNALS.—No. II.

*Proceedings of the Thirteenth Meeting of the British Association for the Advancement of Science.**

Catalogue of the Stars.—Dr. Robinson, of Armagh, announced that the reductions necessary to form this catalogue were completed, and that it embraced the places of ten thousand stars, with the corrections necessary to determine their places at a subsequent epoch.†

Action of the Chemical rays in Light upon Chlorine.—Professor Draper, of New York, finds that chlorine gas which has been exposed to light, possesses qualities not found in chlorine made and kept in the dark. It unites rapidly with hydrogen. The chemical rays corresponding to the indigo in the spectrum, produce this effect in the greatest degree. The effect is permanent, and the light itself is deprived of the rays thus absorbed by the gas.

On the heat of Combination.—The following important law was developed, in a series of experiments, by Dr. Andrews, of Belfast:—"When one base displaces another from any of its neutral combinations, the heat evolved, or abstracted, is always the same when the base is the same; or, in other words, the change of temperature which

* This abstract of the principal proceedings of some of the sections of the British Association, is made from the report in the London Athenæum for August and September, 1843.

† Nearly ten thousand dollars were expended in the computation of this catalogue, and three thousand have been appropriated for its publication.

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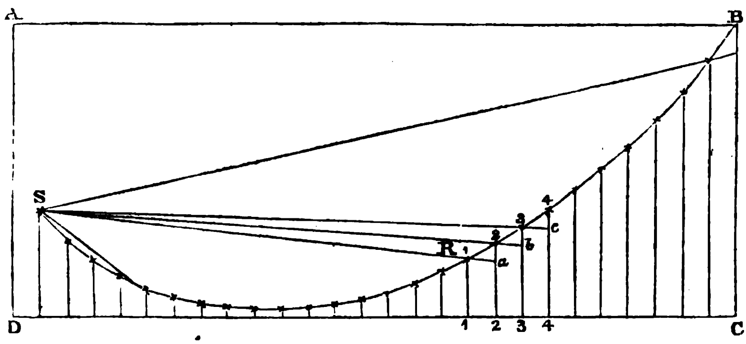
occurs during the substitution of one base for another, in any neutral compound, depends wholly on the bases, and is, in no respect, influenced by the acid element of the combination."

Decomposition of Carbonic Acid under the light of the Sun.—The decomposition of carbonic acid, and the alkaline carbonates, by the leaves of plants under the light of the sun, is found, by Professor Draper, of New York, to take place most rapidly in the yellow rays, the rays of highest illuminating power in the spectrum.*

Form of Lecture Rooms.—Mr. Scott Russell, of Edinburgh, describes the arrangement of a lecture room, the lecturer being placed in the focus of what he calls a curve of equal hearing, or isacoustic curve, and the heads of the hearers by the arrangement of the benches occupying points of the same curve. The arrangement is shown in the annexed diagram.



Let A, B, C, D, represent the vertical section of a building for public speaking; S, the height of the speaker on his platform; D, C, the floor of the building: then, for the purpose that all the auditors should hear and see equally well, they should be placed on the line, S, R, B, of the isacoustic curve. This curve is constructed in the following manner: D, C, is first divided into equal parts, to represent the usual breadth of a sitting, and vertical lines are drawn through these points. R, being the place of the auditor 1; the place of auditor 2 behind him, is assigned thus—join S, R, and produce it to *a*—from *a* upwards set off *a* 2 = 9 inches, and 2 is the proper height of the next spectator. Then join S 2, produce it to *b*, and set off *b* 3 = 9 inches, and 3 is the place of the third spectator; and so on for the place of every spectator. Such was the vertical section of the building. The horizontal section was either circular, or polygonal, having the speaker at the centre. This form had been found perfectly successful in affording the highest degree of comfort both to hearer and speaker.†

* See also Bulletin of Amer. Philos. Soc. vol. iii, Centennary Meetings.

† This principle was applied, by Professor A. D. Bache, in the construction of two of the rooms in the building for the Collegiate Department of the University of Pennsylvania in 1830.

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Expenditure for the promotion of Science.—The sum already appropriated to further the prosecution of original researches, calculations, for the publication of researches, &c., by the British Association, amounts to more than forty thousand dollars.

Observations on the direction and force of Wind.—Mr. Snow Harris deduces from the discussion of observations made at Plymouth with Whewell's anemometer, that there is, on the average, a general motion of the air from south to north. The observations with Osler's anemometer show a general tendency to two maxima, and two minima in the force of the wind during every twenty-four hours, the force increasing as the barometer falls, and *vice versa.*

Tides of the eastern coast of Scotland.—The result of simultaneous observations at twenty-one stations on the eastern coast of Scotland were communicated by Mr. Scott Russell. At particular stations observations of the height of the tide were made every five minutes for one or more lunations. The general results in regard to the tide wave were as follows:

"As in the former observations of the Clyde and the Dee, it had been found in this series, that the form and dimensions of a channel produce important changes in the form of the tide wave. Where the sea was deep, and the shore open and abrupt, the form of the tide wave was symmetrical, and of the form predicted by Laplace, where he says, that in rising and falling, the water covers in equal times equal areas of a vertical circle. This is the form of the ocean tide wave; but, on approaching a shallow shore, and traveling along a shelving coast, the tide wave undergoes two changes—its summit becomes displaced forwards in time, its horizontal chords become dislocated, and the wave ceases to be symmetrical. This peculiar dislocation and displacement are characteristic of a littoral tide, and in the case of running streams, the currents still further affect the tide wave, and give to it a peculiar distortion characteristic of fluvial tides. To these were further added the exaggeration and elevation of the tide, by means of narrow channels. All these phenomena were fully proved by the present series of observations. The author of this paper also considers it to have been fully established by the observations on the Frith of Forth, that there exists on the eastern coast, satisfactory evidence of the presence of a second tide wave in this part of the German Ocean, and that the southern tide wave, a day older than the northern tide wave, sensibly affects the phenomena of that part of the coast: to this he attributes the double tides of the Frith of Forth."

Destruction of Elasticity by small strains.—Mr. Hodgkinson infers from his experiments, and those of Mr. Fairbairn, on different materials, including wrought and cast-iron, stone and wood, that the "sets" produced in bodies are proportional to the squares of the weights applied; and, therefore, that small weights produce a permanent set in bodies.*

* This article will be given in full.

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description of the telegraph thermometer devised by Professor Wheatstone, of London, and to be applied in their experiments with "captive balloons," by the committee of the Association:

"The telegraph thermometer which is intended to be carried up by the balloon, weighs, with its case, about four pounds. It is thus constructed: the movement of a small clock causes a vertical rack to ascend and descend regularly in six minutes, three minutes being occupied in the ascent, and three in the descent. The rack carries a fine platina wire, which moves within the tube of a thermometer; the extent of motion of this wire corresponds with 28° of the thermometric scale, but it is capable of adjustment, so that it may pass over any 28° of the range. Two very fine copper wires, covered with silk, and of sufficient length to reach from the ground to the balloon, when at its greatest elevation, are connected with the instrument in the following manner: the extremity of one wire is connected with the mercury in the bulb of the thermometer, and that of the other wire with the frame of the clock, which is in metallic continuity with the platina wire. On the ground, the lower extremities are joined together; in the wire whose opposite end is connected with the mercury in the thermometer, a sensible galvanometer is interposed, and in the course of the other wire a single, very small, voltaic element is introduced. The galvanometer having been properly adjusted to its zero point, it will remain so during the time that the platina wire is not in contact with the mercury in the tube, but the needle will deviate so soon as the contact takes place, and will remain deflected until contact is again broken during the ascent of the rack. During each half second of time, corresponding with the beats of the clock, the wire moves through the 360th part of its range, and a different point of the range consequently corresponds with a different beat, or half second of each alternate three minutes. If, therefore, an observer below be furnished with a chronometer, timed to coincide with the clock in the balloon above, and note at what instant the needle of the galvanometer is deflected, he may infer from that observation the temperature indicated by the thermometer in the balloon; for, according to the different expansion of the mercury in the thermometer, the contact is broken at a different half second. Should the rates of the two time pieces not exactly correspond at the conclusion of a series of observations, the results will not be vitiated, as a correction may be easily made. It is intended to add to this apparatus a wet bulb thermometer; this will involve only the addition of another platina wire to the rack, and of another insulated wire, reaching from the balloon to the earth, with its interposed galvanometer.

"For other meteorological instruments, the indications of which are to be transmitted to a distance, I occasionally employ the agency of electro-magnetism to ring a bell, to mark with a type, or pencil, &c.; but for the purpose in question, such methods cannot be so conveniently employed as the deflexion of the needle of a galvanometer

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on account of the necessity of having the long conducting wire extremely fine, in order to avoid adding too much to the weight of the balloon. If the electro-motive force of the rheomotor were increased, which it would be necessary to do were stronger currents required, sparks would occur at the surface of contact of the mercury, which would produce injurious effects."

Two new metals.—Professor Mosander in examining the mineral yttria has found two new metallic oxides, the bases of which he calls erbium and terbium.

Geological survey of Great Britain.—Attached to the corps which is carrying on the trigonometrical survey of Great Britain, are geologists who carry on simultaneously with the trigonometrical operations a geological survey. Characteristic specimens of the different strata, and of the fossils contained in them, are deposited in the "Ordnance Museum," which it is intended, eventually, to throw open to the public.

Motion of glaciers.—Mr. Hopkins, with a view to elucidate the theory of the motion of the glaciers, made the following experiments:

"A slab of sandstone, prepared to be laid down as a part of a common flagstone pavement, was so arranged as to be easily placed at any proposed inclination to the horizon. The surface of the slab, so far from being polished, retained the grooved marks of the instrument with which the quarry-man had shaped it. A quantity of ice was placed on the slab, within a frame nearly a foot square, intended merely to keep the ice together, and not touching the slab, with which the ice alone was in contact. The following were results obtained in one set of experiments, the ice being loaded with a weight of about 150 lbs.:

Inclination of the planes,	3°	6°	9°	12°	15°
	Inches.				
Mean space for one hour,	0.31	.62	.96	2.	2.5

When the weight was increased, the rate of motion was also increased. The least inclination at which sensible motion would take place, was not determined; but it was ascertained that it could not exceed *half a degree* in the case of a smooth but unpolished surface. With a *polished* surface of a marble slab, the motion of the ice indicated a deviation from horizontality with as much sensibility as water itself. It will be observed, in the results above given, that (1) the motion was unaccellerated; and (2) it increased with the inclination, and (when the inclination was not greater than nine or ten degrees,) in nearly the same ratio; and (3) the rate of movement was of the same order of magnitude as in actual glacial motion, which may be stated generally, in cases yet observed, never to exceed two feet a day. The extremely small friction between the plane and the ice, indicated by the small inclination necessary to produce motion, was manifestly due to the circumstance of the lower surface of the ice being in a state of gradual disintegration, which, however, was extremely slow, as

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proved by the small quantity of water proceeding from it. In the application, therefore, of these results to the case of actual glaciers, it was necessary to show that the temperature of their lower surfaces could not generally be less than 32° Fahr. Such, the author stated, must necessarily be the case, unless the conductive power of ice was greater than it was deemed possible that it could be."

The temperature at which the experiments were made is not stated.

Earthquakes in Scotland.—In the course of the year from July 1842 to July 1843, no less than thirty slight shocks of earthquakes have occurred at Comrie, in Perthshire.

Permanent expansion of solids by heat.—Mr. Scott Russell states that cast and malleable iron and brass undergo a permanent expansion when heated, not returning, on cooling, to their former dimensions. This is contrary to the results hitherto obtained in regard to these bodies.

Meteorological report.—The abstract, by Col. Sabine, of the report by Sir J. F. W. Herschel, from the committee on the reduction of meteorological observations, embracing the series of equinoctial and solsticial observations for 1835 to 1838 both inclusive, cannot be abridged, and will be given in full in a future number.

Diurnal changes of the magnetic elements.—The reductions of the magnetic observations at Dublin, made under the direction of Professor Lloyd, exhibit the following facts in regard to diurnal changes at that place. The horizontal intensity has two maxima and two minima during the twenty-four hours, the former at 5 A. M. and 6 P. M., and the latter between 1 and 3 A. M. and 10 A. M. The first named are small compared with the second, and disappear in the summer months; in the winter the evening maximum appears to divide into two. The time of occurrence of the morning maximum depends upon the hour of sun-rise. The daily range of force in July is .0045 of the whole intensity, and in January but .0008: the total intensity varies but little through the day. It is least about 9 A. M., and then increases, having a double maximum in the afternoon. The chief apparent changes in the two components of the intensity, the horizontal and vertical, are due to changes of dip (inclination.) The dip is greatest between 10 and 10½ A. M., and least about 6 P. M. The daily range in the early part of the year is about two minutes, and increases to more than double that amount in summer. The diurnal variation (change of declination) follows a different course at different periods of the year. The mean change for the whole year shows a small easterly motion of the north end of the needle in the morning, attaining a maximum about 7 A. M. The north end of the magnet then moves rapidly westward, attaining its extreme position at 1h. 10m. P. M.: the easterly deviation again becomes a maximum about 10 P. M. The mean daily range is about 9.3 minutes. During the summer months the morning maximum at 7 A. M. is more marked, and the

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evening maximum disappears, while in winter the reverse is the case. The greatest daily range is in summer, and about 13.7 minutes; the least, in winter, and about 7.2 minutes. The diurnal changes in the direction of the magnetic force appear to connect it with the diurnal movement of the sun.

Artificial magnets.—Dr. Scoresby finds that for large magnets consisting of many bars, or of heavy masses, the best cast-steel made as hard as possible, is the most effective material; while, for small magnets, or thin compass needles, other steel, or cast-steel tempered, is better. The dimensions of a magnetic bar being doubled, and the bar saturated, the effective force is increased only five or six times. The rule in regard to the use of hard cast-steel for bar magnets does not hold with compound horse-shoe magnets, a softer material being required to produce the most powerful combination with this form of magnet.

*Report of the committee on the form of Ships.**—This report, by Mr. Scott Russell, includes 20,000 observations, on more than one hundred vessels of different forms. It is understood to be now ready for publication. One of the general laws announced by Mr. Russell, is that each velocity of motion has a corresponding form and dimension producing with it the least resistance. In a comparison of four different vessels of the same length, breadth, depth, area, and form of midship section, and loaded to the same weight, displacement, and draught of water, the form of the water-lines being the only difference in the models, the following results were obtained. No. 1, was of the wave form of water-line; No. 3, the "old form," nearly the reverse of the former; No. 2, intermediate between No. 1 and 3, and No. 4, intermediate between No. 1 and 2.

Miles per hour.	Resistance in pounds.			
	No. 1.	No. 4.	No. 2.	No. 3.
3	10	11.3	12	12
4	18	21	22	23
5	28	35	38	42
6	39	56	61	72
7	52	84	96	129

* These experiments have occupied more than five or six years, and have cost more than four thousand dollars.

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